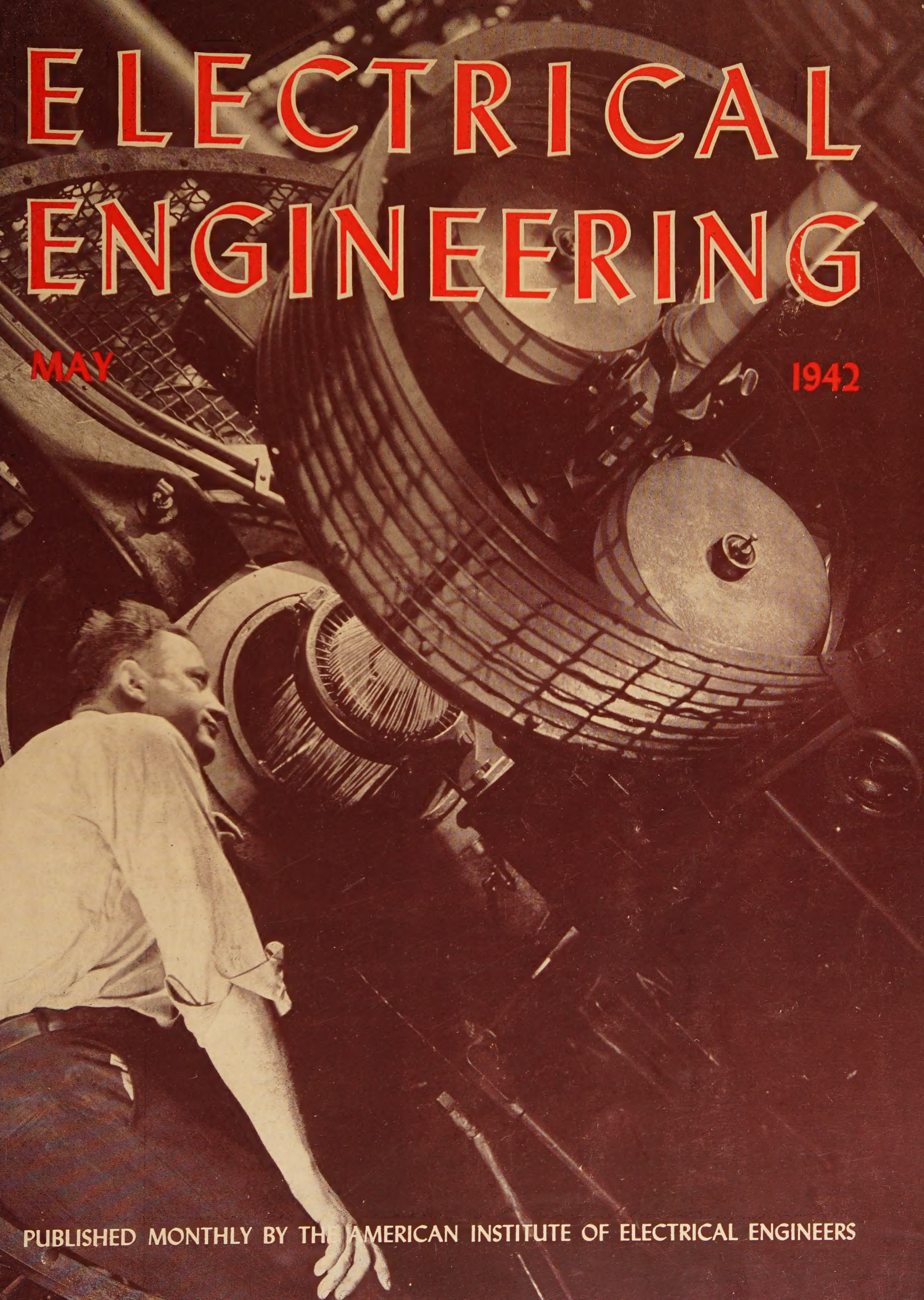
ELECTRICAL ENGINEERING

MAY 1942



PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

HIGH LIGHTS ••

Air-Raid Experience. An AIEE member in London has reviewed the air-raid experience on electricity-supply systems in Great Britain, which should be of value to any American power engineers who may be making preparations for possible aerial bombardment of American soil. The problems are said to be more of an organization and administration type than of an electrical-engineering character (*pages 231–41*). As a special service in this emergency period, and in response to demand indicated by advance inquiries, this article is being reprinted for general distribution. Copies may be obtained from AIEE headquarters, 33 West 39th Street, New York, N. Y., at 30 cents each postpaid, payment to be made in advance; 20 per cent discount on orders for ten or more copies to the same address.

Equivalent Circuits. A method has been developed for the establishment of equivalent circuits to determine the hunting characteristics, such as damping and synchronizing torques, of standard types of electric machinery (*Transactions pages 290–6*); equivalent circuits for a synchronous machine with polyphase a-c excitation on both stator and rotor have been studied on an a-c network analyzer (*Transactions pages 286–9*). The general theory of system analysis by means of equivalent circuits also is discussed in a "Letter to the Editor" (*page 277*).

Variable-Speed Drive. In a system of speed control for very large wound-rotor induction motors, the slip rings of the motor are connected to a synchronous motor driving a variable-speed d-c generator which feeds a constant-speed a-c–d-c set putting the major part of the secondary power back into the line. This system is particularly applicable to motors driving large pumps or fans and has recently been applied to a large wind-tunnel fan (*Transactions pages 255–60*).

Power Systems for Industries. Various basic designs for industrial power-distribution systems, including large concentrated substations and distributed load-center substations with radial and secondary-network modifications, have been compared as to safety, service reliability, simplicity, and other fundamental considerations, in relation to estimated installed cost (*Transactions pages 272–9*).

Correction for Saturation. To determine the actual per-unit excitation for a salient-pole synchronous machine necessary under load conditions producing a certain air-gap voltage, correction for saturation may be applied as a linear addition to the nominal or excitation voltage vector of the two-reaction diagram drawn with unsaturated constants (*Transactions pages 233–5*).

Postwar Planning. To win the peace, we must prepare now, even while we are concentrating on winning the war, says the National Resources Planning Board in announcing the Board's objectives and program for the postwar period (*pages 266–8*); preliminary investigations on postwar planning in Great Britain are reported in a "Letter to the Editor" (*pages 274–7*).

Fourier Integrals. The fourth article in the series on "Advanced Mathematics as Applied to Electrical Engineering" discusses the analysis of systems with known transmission-frequency characteristics by Fourier integrals. The Fourier integral has been called one of the most important mathematical contributions of all time (*pages 248–56*).

Current-Transformer Transients. Quantitative data have been secured on error currents in various sizes of current transformers supplying power-system protective relays; errors have been classified according to the type of relay that can be applied and also according to the d-c time constant of the circuit considered (*Transactions pages 280–5*).

Summer Convention. Plans are progressing for the AIEE summer convention to be held June 22–26, 1942, at Chicago, Ill., and scheduled to be a "working convention" (*pages 257–8*). Abstracts of some of the papers to be presented appear in this issue (*pages 260–2*); others will be published in later issues.

Electrical Definitions Issued. "Definitions of Electrical Terms" a new American Standard sponsored by the AIEE, now available for distribution, assembles in one volume definitions of the important terms common to all branches of the electrical art as well as those specifically related to individual branches (*pages 257–8*).

Power Production. Reports by the Federal Power Commission on all types of electric-power production for 1941 show a gain of 16 per cent over 1940 and of nearly 29 per cent over 1939; percentage increases in the use of various fuels for production of electric energy are also shown (*pages 272–3*).

Converting the Radio Industry. Need for all types of communications equipment by the armed services will require the use of every facility of the radio manufacturing industry to meet the tremendous demand; shifts in production procedure will be necessary to produce military radios instead of civilian sets (*pages 268–9*).

Bus Protection. The use of linear couplers (air-core mutual reactances) instead of current transformers for bus protection has been found to solve the problem of saturation and provide a linear relationship between secondary voltage and primary current (*Transactions pages 241–8*).

Protective Relay for Generators. A new protective-relay scheme for a-c generators has been developed, which operates to remove an underexcited machine from the system upon occurence of resultant undervoltage before loss of synchronism occurs (*Transactions pages 261–6*).

The Second Mile. Every calling has its mile of compulsion, but beyond that lies a mile of voluntary effort, says a leading educational authority, who declares that it is only in this second mile that a calling may attain to the dignity and the distinction of a profession (*pages 242–7*).

Supplying Kilowatts and Kilovars. Increased system kilowatt capacity may be secured by the reduction of kilovar requirements of generators and the provision of reactive capacity sources at other points in a power system (*Transactions pages 249–55*)

Breaker for Heavy Powerhouse Service. Test data have been presented justifying the application of compressed-air circuit breakers utilizing the cross-blast type of interruption for powerhouse service up to $2^1/_2$ million kva (*Transactions pages 235–41*).

Lightning-Arrester Discharges. Data on the wave shape of lightning currents discharged by arresters have been collected by means of fulchronographs, cathode-ray oscillographs, and magnetic surge-front recorders (*Transactions pages 266–71*).

Coming Soon. Among special articles and technical papers currently in preparation for early publication are: an article on the use of alternating current in the United States Navy by H. G. Rickover; the fifth and final article in the series on advanced mathematics applied to electrical engineering, on traveling waves on transmission lines by Ernst Weber (F'34); a paper on the control of tie-line power swings by C. Concordia (M'37), H. S. Shott (A'40), and C. N. Weygandt (A'37); a paper on the analysis of the application of high-speed reclosing breakers to transmission systems by S. B. Crary (M'37), L. F. Kennedy (M'39), and C. A. Woodrow (M'41); a paper on formulas for the magnetic-field strength near a cylindrical coil by H. B. Dwight (F'26); a paper on a d-c telemeter or d-c Selsyn for aircraft by R. G. Jewell (A'30) and H. T. Faus (M'34); a paper discussing an aircraft voltage regulator and cutout by R. C. Jones, D. W. Exner, and S. H. Wright (M'34); a paper on saturated synchronous machines under transient conditions in the pole axis by Reinhold Rüdenberg (M'38).

Released by British Press Service

Effect of Air Raids on British Power Systems

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This review of air-raid experience on electricity-supply systems in Great Britain and the procedures adopted for maintaining service should be helpful to American engineers who may be planning protective measures against possible aerial bombardment of American soil. The problems encountered are said to be not so much those involving electrical-engineering technique as organization and administration.

THIS account is based upon experience gained during the Battle of Britain and in 1941, and is offered to members of the AIEE in an effort to help them, should they become responsible for restoring electricity supplies after air raids. It is realized that conditions in America and in Great Britain are not identical, but it is believed that they are so similar that American engineers will be well able to adapt British experience to their own problems. In any case, wherever high-explosive bombs fall, they always have the same effects. The subject matter has been divided into broad headings, which are thought to be the natural subdivisions in the supply of electric energy to the consumer.

POWER STATIONS

Machinery. Generating units have withstood bomb splinters and blasts remarkably well owing to the sturdy construction of turbine casings and alternator stators, and a bomb need not be very far away for it to fail in its destructive effect. Many undertakings have installed a roofing of sheet steel over the valve gear, which has proved its value, and fires from lubricating systems have not been the worry that was anticipated. Some machines have been encased in brickwork and concrete, and this has been valuable. Heating troubles have not taken place, except around the high-pressure end of the turbine, where additional ventilation has been necessary.

Fabricated condenser shells have withstood shock better than those of cast iron, and great advantage has been reaped by elaborate sectionalizing of steam and water pipework. The duplication of extraction and feed pumps, and arranging for alternative steam flows and feed-water control, has proved of great benefit in maintaining running conditions.

In the boiler house, automatic control systems have been well able to handle the fluctuating loads prevalent in times of persistent air raids. In fact, it may be said that the great stress placed on continuity of supply in peacetime has resulted in a layout and duplication of

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This article includes certain extracts from the author's articles in *Electrical Review*, *Electrical Times*, and *Electrical Industries*, and suitable acknowledgment is therefore accordingly made. The author also wishes to thank J. W. J. Townley, president of the Incorporated Municipal Electrical Association, for his helpful suggestions, and for permission to publish the data in this article.

Reprints of this article are being made available; see facing page.

equipment which have been invaluable in maintaining a similar tradition and good record in the war.

Coal heaps have not caught fire to any disastrous extent, although high-explosive bombs have sometimes scattered the coal in all directions, thereby causing a certain amount of wastage. The normal need to keep such heaps at a certain maximum thickness has meant, however, that the loss has not been serious.

Cooling System. Concrete cooling towers and ponds have successfully withstood the impact of high-explosive bombs. Damage to wood cooling towers has at times been serious, since a blast may strip the whole of the sheeting from the sides of a number of towers in a group. The consequent reduction in the output of the station can be quite serious, even though the rest of the plant is unharmed. Wooden towers have also been damaged by fire from incendiary bombs, and these fires are sometimes difficult to control.

Stores. Stores should be dispersed, since their destruction can be exceedingly serious. Steam jointing material, lagging, grate links, high-tensile bolts, and other materials are in constant need, and a holdup in supplies may have serious consequences. The principles of dispersal apply to many parts of the power station and not least of all to the chemist's equipment. Although a station can operate satisfactorily without the constant checking and testing which is the chemist's duty, yet the destruction of all his apparatus may mean the cessation of such checks and tests for quite a period, so that the undertaking is not only unable to check the analysis of the coal received, but cannot control the state of the boiler water.

Control Room. In the control room, fire protection of cables has already been carried out in most power stations, but the main trouble has been found to be in damage to the control wiring and cables. It is so essential to reconnect absolutely correctly, and the space available is often so limited, that to re-obtain remote operation and indication of equipment after damage can be quite a long job.

Segregation of the small wires from the main cabling, and as much as possible from each other, is the keynote to success. While this is probably hard to achieve in an existing installation, hundreds of yards of spare V.I.R. (vulcanized India rubber) cable will be found an invaluable standby. No doubt this point will be taken care of in future designs, and it is likely that we shall not continue to erect a control room on top of an inflammable switch house, where it would be the first thing to be hit. Neither will cables be run out of the site via one route.

What may seem a very small point in the design of control rooms has had a marked effect upon operating efficiency; this is the matter of alarms. A good number of power stations have a different-toned bell for each type of fault operation. When things go wrong, the control room is filled with the sound of many bells, and naturally this tends to confusion. An improvement has been made in eliminating all bells but one and installing a flashing lamp alongside each alarm-originating device, for example, overload relay, earth-leakage relay, high-temperature alarm, etc. The resulting effect on the emotional behavior of the operator is quite remarkable.

Synchronizing equipment cannot easily be improvized, and it is a wise precaution to erect and connect duplicate equipment in the basement of the switch house.

Auxiliaries. Many items of auxiliary apparatus stand out in the open. As protection from blasts, walls made from hollow concrete or breeze blocks, cemented horizontally and filled with sand have been found most successful. A cheaply constructed sloping corrugated-iron roof deflects a certain amount of the lighter debris, although something more substantial is needed to stop the incendiaries, bricks, and stones which often fly about in air raids.

To provide more complete protection the walls, which must be not less than 14 inches of brickwork or 18 inches of breeze blocks, should be built a little higher than the gear to be protected. A flat concrete roof should then be put over the area, resting on piers built up from the walls and maybe with supporting stanchions inside the area covered. A space should be left between the top of the wall and the under side of the roof of about 12 inches. This space can then be covered with a heavy-gauge expanded-metal sheeting so as to give ventilation.

Buildings. In some of the older power stations the architecture ran to long high buildings and slated or tiled timber-framed roofs; the latter often had many dips and valleys in which an incendiary bomb could lodge. On the large-spanned roofs, like those of the engine room and boiler house, any major reconstruction is impossible.

Any glazing in the roof should be replaced with some material that will not splinter into death-dealing fragments, like glass. Some undertakings have favored the substitution of glass, slates, and tiles by sheet steel, and in painting this, have taken the opportunity to do some camouflaging. This latter can well be applied to all the buildings on the site, as is done at many stations, but its design is a matter of considerable skill and should be executed by a specialist in that line.

Reverting to roof construction and its reconstruction, other power stations have been equipped with corrugated iron and corrugated asbestos or other type of fire-resistant material in place of the glazing. A prime consideration is the weight that the roof members will stand, but the objectives to be achieved in any modification are two in number: The first is the elimination of anything that might of itself cause injury to staff or damage to apparatus when it is hit by even a small object, such as shrapnel or an incendiary bomb; the second is to do away with anything that might catch fire, either from an incendiary bomb lodging on the

roof or a fire inside the building. It is often possible to lay sheets of fire-resistant material in the valleys of the roof covered with about three inches of sand, which does not impose too great an additional weight and certainly not too great a bending moment; this is often found to be quite effective.

For the smaller slated or tiled timber roofs replacement with 6-inch-thick flat concrete, covered outside with a 1-inch-thick layer of asphalt is excellent. As to windows, it often will be found that many may be eliminated and therefore bricked up. It is important to make sure that the new brickwork is properly keyed into the existing walls, and this sometimes involves more time and labor than would be estimated at first glance. Other windows can often have their glass replaced by wired-glass.

Mobile Equipment. At many power stations cranes and telphers are limited in their range. Both must keep to a predetermined track; but in wartime occasions arise when it is valuable to have a small mobile crane available. It can be used to store coal on any new ground that may either be vacant or be made available by the demolition of property. Such a crane can be invaluable if heavy broken masonry or apparatus has to be removed so as to get machinery going again, or more important, rescue operatives.

Under the heading of substations mention is made of the value of mobile transforming and switching equipment.

Communications. Nothing is so disconcerting as the loss of communication, and so it is a wise precaution to put all telephone lines underground in the power-station yard. Furthermore, the telephone service should be approached about the possibilities of running the lines underground throughout the whole length back to the exchange. Most power stations have at least two lines coming in, and it is advisable to try to get these put underground by different routes, not only inside the premises but also outside.

Operating Conditions. The problems of wartime are not, however, all bound up with air-raid protection; many alterations have been made in operating conditions too. The latter are, of course, much more variable than those connected with protection of apparatus, and each power station will have its own special problems.

Coal supplies are not so consistent as in the past, and the variation in quality imposes increased duties on the combustion engineers. More care is necessary not only in discharging the different types of coal from the wagons, but also in ensuring either an even spread of the different types throughout the bunkers or the allocation of certain types to specified boilers.

Following this, it becomes much more important to ensure proper firing for a number of reasons. It is vital to keep as much plant in commission as possible, so that there shall be the maximum amount of "cover" on the system in case of damage by enemy action to plant in other stations. Secondly, it is essential to keep repairs to grates and brickwork to a minimum, not only because of the increased cost of materials, but also because of the difficulty in obtaining or retaining skilled men to execute the work. A third reason for economical operation is the desirability of using as little coal as possible because of its continually increasing cost. And lastly, even if coal were not dear, its delivery is encumbered with so many difficulties that it must be used sparingly and conserved as much as possible.

All this not only entails the operation of the plant under its best operating conditions, but also the investigation of methods of improving present practice. Among those which readily occur to mind are experiments with moisture addition for the various types of coal, and an investigation into its place of application, that is, on the conveyors, in the bunkers, or into the grate hopper.

Maintenance. Bombing of the distribution network has an effect in the power station, because any cable fault between the switch house and the first substation supplied by the feeder will operate the power-station switchgear. This will mean an increase in maintenance and calls for good liaison work between the generation and distribution staffs. These increased operations will mean increased duty on the tripping and closing batteries and therefore will necessitate more frequent charging and overhaul. This is only a small point, but it can be frequently overlooked in busy times. In fact, wartime conditions do have quite a considerable effect on small matters in the power station. Things which were only infrequently done and gear which was examined only now and then, need much more frequent attention because of the changing operating conditions.

In these times it should be the aim of every power station to keep as much plant in commission as possible and to neglect no reasonable steps to safeguard the equipment from breakdown.

SUBSTATIONS

Substations, like power stations, withstand an enormous amount of punishment; unless they receive direct hits, they seldom sustain worse harm than blown-out doors, windows, etc. But even if in the case of the less substantially constructed units, serious damage is done to the structure, the chances are that the transformers, switchgear, and other equipment will still be serviceable.

Rotary Converters, etc. With regard to rotary-converter substations, several raids again emphasize the importance of being ready for all emergencies. The precaution had been adopted by some undertakings of building frameworks over the machines, and covering them with galvanized-iron sheeting. This arrangement has undoubtedly prevented serious damage from falling glass and burning timber.

In addition to damage by falling debris from blasted buildings or road surfaces, a considerable danger arises from the floating of mud into the windings of machinery. The mud also has a tendency to pack underneath the brush gear almost like granite, and the windings become one solid mass. The necessary protection is easily afforded by means of shields. Where roofs have been lost by blast, portable canvas structures are proving invaluable for enabling the machines to be restarted in minimum time and also for protecting them from the weather.

Naturally considerable damage has been caused to plant in some instances by water, but in practically all cases it has been found possible to dry out the equipment without further injury. A further complication is met in certain coastal areas where salt water is employed for fire fighting. Some engineers have contemplated washing the plant down with fresh water, but this practice has not been generally adopted.

Switchgear. It has been remarkable how well modern metal-clad switchgear has withstood the effects of high-explosive bombs dropped onto or alongside the buildings in which it is housed. Falling debris has been withstood best by gear incorporating fabricated structures rather than cast-iron, and having bakelized-paper bushings instead of porcelain. Metal-clad switchgear has also successfully withstood fire, and few instances are known of fire being caused by an electrical breakdown in the gear itself. The most common cause of fire in air raids, with regard to electricity supply, is ignition of a timber-frame, slated or tiled roof on a substation building. Here the disadvantage of having compound-filled bus bars on the top of the gear becomes apparent. Considering the few cases in which this type of gear is installed in such buildings any modifications are unnecessary. The use of oil-filled bus bars is naturally no improvement, and air insulating is impractical.

With sheet-metal-cubicle gear, blast plays havoc and usually results in more or less complete destruction. Porcelain insulators are shattered, and the switch-tank top, usually a casting, is often broken. Cubicle gear withstands the effect of fire remarkably well, especially if the top is covered with fire-resistant blocks. These latter were originally developed for building light walls and floors, and if used in slabs of 12 by 24 inches with a weight of 57 pounds per cubic foot, are very convenient. They can also be used for protecting metal-clad switchgear, but here the structural shapes of the gear are not so convenient for simply laying the fire-resistant slabs on top of the gear. It is sometimes found practical to erect a light angle-iron framework over metal-clad gear and lay the blocks onto this framework.

Sheet-metal-cubicle gear is easily dried out (preferably with electric radiators rather than paraffin blow lamps) but care is needed before putting it into service again. The most frequent trouble has been the fracture of porcelain insulators inside their cast iron clamps, caused either by heat or by movement of the open-type bus bars.

Transformers. Curiously enough old transformers have often withstood bombing better than those of more modern construction. The heavier form of tank and the more massive terminal gear have given good service in these times. These remarks are not to be taken as applying to the "turn"-type tank with castings at top and bottom, which are bound to be very vulnerable to both blast and fire. Undertakings which have standardized weatherproof gear, regardless of the situation of the transformer, have gained in air raids. Not only is it possible to move them about and install them in emergency without having to consider protection from the weather, but outdoor transformers have been found to withstand fire hoses being directed upon and around them when burning material has fallen on them. Experience has shown that both transformers and switchgear have successfully withstood repeated electrical surges caused by faults and switching.

Protective Systems. Protective systems also have stood up very well to air-raid conditions, and the nonpilot systems have shown that they are not to be scorned. In fact, with a proper system of grading, the simple inverse-time-limit overload induction relay has proved most reliable, on general high-voltage distribution networks. When a number of the substations include gear incorporating time-limit fuses, correct grading with the foregoing type of relays can be obtained with a little thought and careful investigation, and correct discrimination secured.

Where the protection depends upon pilots, constant testing is necessary to ensure that all cores of the pilot are still intact and that the relays will operate when required. One disadvantage with normal relay cases is that they have glass fronts; this allows debris to enter the instrument, and even if it does not cause unwanted operation it usually entails the removal of the relay for cleaning and overhaul. It is often the practice to set transformer high-voltage-switch relays at a very small time delay, and in some instances these have tripped because of vibration from nearby bomb explosions.

Stocks of Material. It is vitally necessary to hold considerable stocks of metal-clad switchgear, transformers, high- and low-voltage cables, low-voltage fuse gear, and a large assortment of spare parts. The purchase of these may put a strain upon the undertaking's finances, but if the stocks are well cared for, they will be good for use after the war, and their value will be all the greater when prices are high.

It is remarkable how well the emergency gear designed in peacetime, has gone together when required in these days of stress. The times for putting into commission have not perhaps been so spectacular as was at first thought possible, but then it certainly is a prob-

lem to erect switchgear, place transformers, and lay and joint high-voltage cable on a crater-riddled site, littered with the remains of the original gear.

Building Construction. All buildings incorporating cement mortar have well repaid this additional expense in their ability to withstand shock and blast. Buildings have rarely fallen down through damage to the structure, although sometimes the walls are so badly broken that they have to be taken down and rebuilt. In modern buildings having concrete roofs, the weakest part of the structure seems to lie at the dampproof course in the walls.

Instances have been known where the whole building above the dampproof course has moved bodily for a distance of two to three inches, without producing cracks or breakages in any other part of the structure. Where a building has a timber-framework roof, covered with slates or tiles this is usually the weakest part of the structure. As a safeguard against fire risk, the woodwork can advantageously be treated with a fire-resistant paint.

Steel doors have generally proved themselves better than those made of wood, although in the larger sizes, there is not much to choose between them. Both types are usually blown off their runners, and although wooden doors may be splintered into many small pieces a new one is quickly made; whereas a steel door, if it be bent or buckled, is difficult to straighten or replace. All doors of a normal size usually have only one lock, probably of the night-latch type. These locks with their brass tongues and cast-iron keys are shattered in hundreds and a large stock of spares is essential if recourse is not to be made to wire and rope to hold the door closed.

Many substations have open transformer chambers, and it has been found invaluable to build hollow concrete walls in front of these. They should be filled with sand and cemented horizontally. Use can also be made of sheet iron where a three-foot space between upright sheets can be filled with sand or cinders, or alternatively a three-foot sandbagged wall can be built in front of any opening in the building. The walls should be placed at such a distance from the building as to leave sufficient space for the removal of equipment if the need arises. In some cases, these walls have remained standing when the whole of the building, if it was built of lime mortar, has been demolished.

UNDERGROUND CABLES

General Experience. Cables and their joints after the impact of high-explosive bombs have continued to operate when bent to far sharper radii than the makers recommended. Cables, especially the high-voltage type, have stretched when on the edge of a crater, and have not parted their joints. Sometimes a cable has been forced a good distance out of its normal run and, in a few cases, joints that were originally in a box in the pavement have been pulled up inside the cable duct. However, they have continued to function. It is debatable whether it is better to "snake" the cable, or cut out a section to get rid of the stretch, particularly where cable is laid directly in the ground. Both methods have been used; cutting out of cable is the more expensive as it needs a new joint, but "snaking" means drawing up a new record so as to ensure finding the cable at a later date.

Cable Ducts and Diversions. Although many cables and joints have triumphantly withstood very severe treatment, and have perforce been left to carry on, yet it is possible that in years to come faults will develop which can be directly attributed to this kind of damage. Some discussion has taken place on the relative merits of building a new duct line across a crater or making a diversion around it, when it is necessary to put a cable into service again before the crater has been filled. Here the actual circumstances often determine the method to be adopted, for in poor-property districts, a bomb crater may extend from house to house, right across the road.

It then becomes necessary to lay a new duct run, or else to build up a structural framework which can support the cables as they traverse the crater. When a bomb falls at the base of a building and parts the cable in the pavement, the road is so littered with debris that it is impossible to get at the damaged cable and a diversion is necessary.

The foregoing remarks refer in the main to high-voltage cable. Methods of dealing with low-voltage cable faults depend upon the nature of the bomb damage. If, for example, property is demolished and the service cable only affected, then the ground can be opened and the cable pot-ended. For this, use has been made of both iron boxes and lead sleeves. The job is permanent and the main distributer is not interfered with. If, however, property is demolished and the distributer is damaged or severed in a crater, a temporary quick repair is generally effected in order to restore the supply to adjacent property. This can be done by pot-ending the cable at each side of the crater, some undertakings using metal or wooden boxes, others preferring lead sleeves. Usually these are filled with ordinary compound or with a special type of coal filling compound, although the latter is not favored by all engineers. The supply is then restored from either end. Should the debris prevent access to the cable in the crater, the cable is usually cut at a point remote from the crater and pot-ended in the same way. In making emergency repairs at craters the cables are often trenched in the road surface or slung on poles across the crater. In all cases of damage, the effect on the network has to be considered. Where the network is a small section and a large distributer feeds both sides of the fault, then the small distributer will normally be left permanently open

at that particular point and a permanent pot-end made.

One of the greatest difficulties affecting cable repairs has been the presence of water. When floods occur after the whole cable has been severely shaken by bombing, any weak points in the cable system are likely to develop into faults. As may be appreciated, the job of repairing cables under flood conditions is arduous and much ingenuity has to be used. Usually it is necessary to make the joints a considerable distance from the crater. Mobile petrol-driven fire pumps are found to be of great value for this work, as well as other pumping devices.

RENEWING BOMBED APPARATUS

General. In Great Britain, bombing has resulted in a general discovery among the ordinary public, that electricity furnishes the most convenient and most readily installed means of providing emergency lighting, heating, cooking, and ventilation, as well as many other services. Coupled with this is the fact that the scarcity of certain raw materials and the general concentration of electrical manufacturers on products of more vital need to the war effort, have all combined to reduce the output of new appliances, not to mention replacement parts.

Stocks and Co-operation. The putting out of action, therefore, of large numbers of appliances by bombing greatly emphasizes the difficulties and renders more and more essential the possession of an efficient repair and maintenance department by the supply authority. Otherwise the undertaking's service is bound, sooner or later, to become seriously impaired.

The position of an undertaking with regard to stocks and replacements, of course, varies considerably according to the district, to whether it is a reception or evacuation area, and to the extent of the enemy's attention. The section dealing with the supply authority's gear for the distribution system stressed the importance of holding a large stock, commensurate with the undertaking's resources. This principle applies for consumer's apparatus, especially on the domestic side, but is probably of greater importance in Great Britain where so much of this kind of apparatus is hired to consumers.

Whatever may be the position at the start of bombing, as the war proceeds the need for repairing and returning every available piece of apparatus will make itself increasingly obvious. Co-operation between undertakings of which the requirements of apparatus have changed is also necessary. Even before the war, repair shops were kept busy dealing with routine repairs relating to all types of apparatus. With the advent of bombing, a much greater strain is placed on resources, and it has often been necessary to increase the number of employees to deal with the situation. This is so, even when the total number of consumers has actually decreased because of the air raids.

Cleaning. When apparatus is removed from bombed premises, it is stored at one of several depots or substations. Never more than 200 appliances should be kept on one site. This dispersal minimizes the risk of large quantities of appliances being damaged by one incident. From these stores, equipment can be taken to the repair shops as required.

All the apparatus taken from bombed areas is not damaged, of course, although complete stripping down and cleaning almost always is needed, and the replacement of minor components is necessitated. It is somewhat difficult to give a fair figure for the proportion of apparatus that can be made serviceable out of a given quantity. In the first place, good parts from several pieces of apparatus are combined to make a complete unit. Many otherwise complete units are, perhaps, held up for the lack of some small component such as a door spring or thermostat. Furthermore, according to present practice it is inevitable that the least damaged units will be selected from the scores for repair first. So far, however, it can be said that approximately 60 per cent of the apparatus has been returned to service in first-class condition.

STAFFING OF UNDERTAKINGS

Supply Engineers. The successful record attained by electricity undertakings in maintaining supplies under wartime conditions, is very largely a reward of past staffing policies. Tribute, of course, must be paid to the excellence of the equipment installed and to the layouts devised. But to the electricity-supply engineers must go the major credit, for it is they who not only have planned the arrangements that have worked so well in air raids, but also have often shown such initiative in making successful expedients.

Early Arrangements. At the outbreak of hostilities many undertakings set up a system whereby there was always an engineer on duty at the head office, together with jointing and fitting staff. The engineers were often of a high caliber, and with the quietness which prevailed in the initial stages, it became obvious that the burden being carried by the undertaking was too heavy. Not only had the men to be paid special rates for standing by outside normal working hours, but they were not available for the usual activities of the undertaking.

Some undertakings then returned to the peacetime practice of keeping the distribution engineers on a stand-by rota, at home, while retaining the jointers and fitters at the head office. For the generating station it became the usual practice to have on stand-by one of the day-duty engineers staying at home, with the fitters standing by at the station. Gradually the extent of stand-by was reduced; jointers and fitters returned to normal work, and in some cases it became the practice to have only a junior engineer on duty outside office hours, who would route any complaints to the appropriate officers concerned. For such work as this, some

undertakings indeed left only a superior type of clerk to handle anything unusual, since most undertakings already have a staff on duty, night and day, to handle normal service calls.

Adaptation to Circumstances. The few air raids prior to the Battle of Britain, were easily handled by the small staff on duty. But during August 1940, it gradually became necessary for all the staff to report for duty immediately after a raid. When September came, all this was altered and many preconceived ideas and plans were sometimes shown to be inadequate. It then became necessary for all the distribution staff to work from dawn to dusk, and during the evening, when air raids were in progress, to stay at the office, making up reports and records. Not for them was the easy path of going home early in the afternoon, like many office workers. They were not bothered about traveling before black-out, for it was they who had to see to it that all transport kept functioning, so as to get workers home before the worst of the raiding began for the night.

Members of the generation staff too had to modify their arrangements, because they found it increasingly difficult to get to the power station to relieve the evening shift, and for the latter to get home. So it was that many of the distribution engineers slept all night at the mains office (probably their families were evacuated). Many of the men were bombed out of their homes and slept in the shelters at the head office and the power station. The generation staff worked two shifts a day, 9 a.m. to 7 p.m. and vice versa, with an appropriate number of days off; most distribution engineers never got any time off, for raids went on every day in the week.

Comrades were injured and killed during both the day and the night, but still the staff kept on, maintaining the fine tradition they had set up. And they did not earn so much public recognition as some of their opposite numbers in rival industries, for their commodity was not so inherently dangerous. But they too had to brave the raids and restore supplies and repair apparatus.

Gradually, the increase in intensity of the nightly raids, with the interspersion of what we have now come to know as "blitzes" or sharp raids, made undertakings realize the danger of having too many men congregated together. The principle of dispersal is really more important for personnel than for stock material and stores. In any case, the growing dangers from incendiary bombs and fire made it necessary to man some of the key substations, even if others could be considered fireproof and put under the care of fire watchers of industrial consumers. This provided a certain measure of dispersal for the distribution staff, but this same danger provided a greater congregation of personnel at the power station. The ordinary staff at the latter could not be expected to deal with fire perils, especially if there were wooden cooling towers, and so a formation of home guard or other such company of men had to be given the task. It often became necessary to recruit such men from among the clerical grades in the accounts and meters sections of the undertaking, so as not to impose too great a burden upon the operating staff.

Lessons From Experience. It can hardly be said that conditions have now become stable, but the experience of many hundreds of air raids, lasting from a few minutes up to many hours, has enabled certain ideas to be clarified.

Since black-out precludes all possibility of jointing being carried on during the night, there is no need to keep either a jointer or mate on stand-by duty at the mains depot. Some undertakings put their foreman jointer on the telephone, while still others retain their jointers on a rota at their homes. Another method is to arrange for these men, as well as fitters, to report for duty immediately after the cessation of a heavy raid. For small raids, men on a rota are detailed to attend.

For the same reason fitting staff at both the power station and the mains office need not be kept on duty during the black-out, although work started during the day can be completed during the black-out. This is always providing precautions are taken for screening lights, and valuable work is often done during air raids under these conditions.

The dangers and perils of bringing a stand-by engineer from his home to the mains office to deal with urgent restorations during a raid have now attained such proportions that it is a wise plan to keep one on duty at the office every night. Moreover, fire is an ever present danger for substations, and system switching needs speedy attention if a fire gets sufficient hold to necessitate the isolation of supplies while firemen operate. Certain supplies, such as control centers, telephone exchanges, and hospitals, need as quick a resumption as possible.

On many undertakings, distribution engineers are provided with a small car, but even if a lorry with driver is kept on stand-by duty, this is not sufficient staff to deal with extra-high-voltage switching, etc. (In British practice, "extra-high" voltages begin at 3,000 volts.) To cater for this, it is useful to have a substation inspector and his mate, or other similar grade of workman on duty, so that they will be available to assist the engineer in switching operations, lifting of box-hole covers, location of craters, and other duties.

At the power station, the normal staff is sufficient with the augmentation of a special squad of fire fighters or a home guard unit formed from the staff of the undertaking. In some stations they have reverted to the practice of keeping one of the day-duty engineers of the maintenance and operating staff on duty each night, so as to help the charge engineer wherever possible.

The consumer side of the undertaking need be no different from the normal peacetime staffing, where such arrangements provided service mechanics on duty throughout the night.

While no management would dream of resting on the known enthusiasm of its engineers, still this keenness on the part of the staff lightens management's burdens. It means that, given both help and encouragement, the engineers and the men will co-operate, improvise, and if necessary work long hours under dangerous conditions, without thought of special reward, just to uphold the status of their profession.

ORGANIZATION FOR MAINTAINING SUPPLY

Preparation. Whenever possible, plans must be matured before trouble happens. It is well-known that actual happenings are often far from complying with the hypothesis drawn up beforehand. A broad outline will often provide the initial basis for action in the first stages when the full tale of damage is not known. It is wise always to imagine that the worst will happen and never be consoled with the thought that trouble may not have to be met. When the actual incident occurs, the staff is immediately heartened by having something better to handle than had been planned for.

An invaluable help to the operating staff when working under air-raid conditions is the compilation of a list of priority supplies. In peacetime it is often found to be a source of contention between the distribution and the generation departments, as to which feeders could be switched out in times of trouble. Now that certain supplies have definitely been given a measure of priority, the problem of discrimination between consumers is easier.

A simple expedient which has been found helpful is to attach a label to the particular low-voltage distributer in the substation from which priority supplies, such as for sirens, are given. This should also give details of alternative feeding arrangements, for no engineer can memorize the whole network. For extra-high-voltage consumers, the switch label will be sufficient for this purpose, but an invaluable help to the staff in the speedy restoration of supplies is the provision of a small portable, straight-line diagram of the extra-high-voltage system. These are often somewhat difficult to keep up to date; but if one draftsman is detailed to make all necessary alterations to comply with changes in feeding arrangements and abandonment of cables caused by bombing, then the problem is not insuperable.

All undertakings have found it necessary to have detailed high- and low-voltage street maps and record cards for the respective networks. Duplication is vital, and photographing of these maps and records and their storage well outside the town or the target area, is of great value. Again there will arise the trouble of keeping such records up to date, but this can be done with persistence, and it is very important never to congregate all the records in one place for alteration. It may well be, that the drawing office will be bombed that very night, and then everything is lost. Maps and records should be amended at the place where they are kept.

A number of copies of the stock list of switchgear, transformers, cables, fusegear, batteries, etc., should be distributed around the undertaking's area, and these can be fairly easily kept up to date. Small requirements for replacements can probably be met from the main stores, and the use of emergency stock will be confined to rather large movements. In this connection, the proper continuation of requisitioning, booking, and costing must be rigidly insisted upon. All requisitions should pass through the person who controls expenditure and the purchase of equipment, so that stocks may not be allowed to fall too low. This is especially necessary in view of the long delivery periods now ruling and the need for permits and authorizations. Good stocks of material should be built up, and this is the time, if ever, when everything should be regarded as having a possible use.

Restoring Substations to Service. Whenever a substation has been involved in fairly serious damage, it is well to be suspicious of the quality of all the contents. Even if all the gear looks to be intact and undamaged, it is well to make a most thorough examination. In many cases it is vital to restore supplies as quickly as possible and energize the gear regardless of any undetected faults. As soon as a lull occurs it is a valuable precaution to take the gear out of commission, so as to determine whether any incipient faults are present. This will mean a temporary rearrangement of the extra-high-voltage and low-voltage network feeding layout, and it may seem a waste of time. Be re-assured; it is not so.

The shock of nearby explosions often causes hairline cracks in porcelain insulators. These may lead to later breakdowns which will burn away the through conductor or any contacts held by the insulator. Such a fault may even melt any metal enclosures and set fire to oil or compound fillings. Cracks have been found on the lead wipes at cable boxes, providing means for the ingress of moisture. Both instrument and relay movements have at times jumped out of their jewels, or the jewels have been fractured. Transformers have been known to jump and produce small flashovers on their terminal gear. While they may continue to operate satisfactorily, the copper beads left on the connections reduce the effective clearances, and may cause more serious arcing later. On cubicle switchgear it is well to treat all porcelain insulators with caution, for cracks and fractures have often been found inside the metal clamps. Such insulators will sometimes successfully pass a long pressure test at an excess voltage, but an insulation resistance test will usually disclose the failure.

Switchgear Testing. Where a whole switchboard has been damaged, be it by blast, bomb, or fire, it is good practice to hand the restoration work over to the maker. This relieves the undertaking's own fitting staff, and possibly ensures a more minute and thorough examina-

tion of the gear, since the maker's staff will be more familiar with the equipment. It is wise to examine all oil and filter it if necessary, but under no circumstances should it be thrown away. Even if no use can be found for it on the distribution system, it can certainly be used as a lubricant for coal conveyors and the like.

When the overhaul is complete, it is essential to check the electrical operation of relays and meters in place, and then the whole equipment should be tested for insulation resistance, voltage tested, and then tested for insulation resistance again. If possible, it is well to impress the testing voltage for a considerable time, and it is also best to choose as high a voltage as possible. There is still much controversy in Britain on the subject of a-c versus d-c voltage testing, but it is generally found that the latter is easiest and most convenient to apply on site with a portable set.

Where substation roofs have caught fire and fallen onto metal-clad switchgear, the damage has not been great. In the main, repairs have been confined to renewals of the small wiring, meter cases or glasses, and perhaps some of the compound filling. When both meters and relays have been damaged it is often best to disconnect all those affected and return them to the meter or relay department for overhaul. The opportunity should then be taken to retest and calibrate the relays, especially those of the overload, inverse time limit, induction type.

Released by British Press Service

Engineers repair the damage to telephone cables caused by an air raid

Transformer Testing. In many substations the transformers are of the indoor type; and if a fire has taken place and water has been liberally used, it is likely that the insides will be moist. Even with outdoor transformers that have been subjected to a hose, there is a possibility of water gaining access because of the lead wipes melting at the glands. Similar trouble may also occur through the cover buckling from heat. In every case where a substation has been seriously damaged, either by explosion or by fire, it is wise to take samples of oil from the transformer. A simple "crackle" test can be performed on site to discover the presence of moisture, but it is better practice to send such samples to the chemist's laboratory. This will enable a breakdown test to be made, together with a correct determination of the electrical and chemical qualities of the oil. A useful feature of making this a standard practice is that it will often show the presence of acidity which may not have been suspected or shown by corrosion.

Acidity is a subject of growing importance, and considerable investigation has recently been carried out. It may be that some of the old oils are very dark in color and contain sludge and fiber. Even if they are wet as well they should not be thrown away, but, like switchgear oil, they should be filtered for later use. Where a transformer has been found to contain acidic oil, the old oil can be used as a refill. No matter how thoroughly the core, windings, and tank be cleaned, and the tubes scrupulously brushed and scraped, yet the acidity will remain; and when the transformer is again put into service, it will increase fairly rapidly. In peacetime it was the practice in Britain to take tests at six-month intervals when this condition had been discovered. It was usually found that when a transformer had developed acidic oil, and had been cleaned and refilled, the new oil reached dangerous limits after about three years' service.

Voltage testing of the transformer is carried out on the same lines as for switchgear, and all associated cables are included in the test.

Reorganizing Networks. Where a substation has been completely demolished, the opportunity should be taken to replan the contents. Not only is it possible that the extra-high-voltage switchgear is of an old type with too low a rupturing capacity, but possibly a rearrangement of both the high- and low-voltage networks can be made to advantage. It should be axiomatic never to leave out of commission for long periods any general distribution substation. While the load can probably be carried by those on either side, yet it can never be known when one of these other substations might be lost. Although it may seem to add to the delay of recommissioning, it is wise to prepare plans of the substation layout proposed,

the type and size of gear to be installed, and any rearrangement of networks. These should be scrutinized thoroughly before putting the re-erection and reconnections in hand.

One of the difficulties facing men repairing services to consumer's premises is the location of the mains. When a demolition party has been active, landmarks such as party walls may have disappeared completely over a considerable area, and the layout plans of the cabling may prove useless. Another complication is that it may be necessary to disconnect a large number of premises to restore the supply to one consumer. Incidentally, a serious problem will face supply authorities after the war, for in badly devastated areas many roads and the cables in them will not be required where they were before.

Sometimes domestic property is badly shattered but the electrical services remain intact up to the main fuses. In these circumstances, they are left until some decision is made by the appropriate authority as to whether the houses are to be repaired or demolished. When the demolition squads get going, quite large areas can be deprived of electricity supplies, if effective liaison work is not maintained. In some areas the leveling of houses proceeds at such a rate that the only course open to the supply authority is to cut and pot-end the main at the end of the street. Care must be exercised, however, for if this practice be taken too far, serious inconvenience may occur through loss of adequate interconnection between substations.

On tramway undertakings it is essential that before the trolley system is energized great care should be taken to make sure that the negative rail feeders are not severed; otherwise there is a grave risk of raising the rail potential.

One mitigating feature of the widespread bombing in some districts, has been that it has substantially helped in the change-over from direct to alternating current. It is obviously not desirable or economical to re-establish d-c supplies where considerable damage has been done to substations and mains.

Some undertakings in areas where the gas works has been put out of action, have had to face enormous increases in demand. Though the reduction in loading caused by premises being abandoned has assisted in keeping the load on certain cables within a safe limit, the load often needs to be kept under constant supervision. Following a raid it may be necessary, if the load becomes too high, to switch out certain sections of a network altogether, although it is preferable to transfer load from one feeder to another and generally spread the increase over as many cables as possible.

Communications and Transport. A number of points have arisen in the actual running of a distribution network under the present arduous conditions that may be worthy of particular note. Possibly the greatest source of inconvenience, and at times exasperation, is the failure of communications. Private lines between the head office and key substations, and between the former and generating stations, are in some ways an added responsibility. Their main advantage is that their repair is under the control of the undertaking itself. While it should be an axiom to give out as much work as possible to makers and suppliers, so as to relieve the undertaking's own staff wherever possible, yet this principle must be related to the speed and efficiency with which the work can be done.

It should be realized that after an air raid the first duty of the telephone-service undertakings is to deal with military and similar requirements. There are a great number of other people who have some sort of call for restoration of communications; hence this dictum: If the supply authority can repair its own private lines quicker than the telephone service can mend its lines, then private lines are the means to use.

The priority consumers can be helped to play their part in securing quick restoration of supplies by giving them a list of telephone numbers and addresses of officials of the undertaking. In addition, a list of premises to which messages can be delivered has been found of great value. During severe raids some undertakings have found it advisable to amplify these arrangements by publishing in the press the addresses of officials in the various areas to which consumers of all classes have been invited to make their requests for assistance. The press can also be used to ask the public to restrict the use of apparatus during certain hours, if feeders or substations should become temporarily overloaded because of damage to normal equipment. The public has been found to respond admirably to requests of this nature.

After essential services have been restored, some undertakings have established a sort of flying squad, to visit damaged premises. They carry out the necessary first-aid repairs, reconnections, disconnections, and insulation testing to enable supplies to be used at the earliest possible moment.

A valuable reinforcement to communication is the adequate, and perhaps lavish, provision of transport. It is essential to get messages from point to point with minimum delay, and even the humble bicycle has proved its value for this purpose.

The whole subject of transport is worthy of critical examination, for by its lack the initial keenness of engineers to get on the job is often dulled by having to wait around for a car or lorry to take them out. Small vans, fortunately so popular with undertakings in Britain, have proved invaluable. Their great use is in the transport of an engineer, a fitter, or a jointer, to the scene of an incident, so that a start can be made as soon as raiding conditions permit.

CONCLUSIONS

Much of what can be done is conditioned by what has been done in the past. If peacetime policy has resulted

in the liberal provision of cabling in the streets, with a good number of substations, and a running stock of switchgear, transformers, and cables, then the supply authority is in the best position to handle trouble. It has not been found necessary to make mobile substations, although small mobile generating sets have been used to give partial supplies to industrial consumers.

The main lesson to be drawn from the experiences and recommendations reported and presented herein is that the problems to be handled are actually not so much those involving considerable electrical-engineering technique, but rather are they concerned with organization and administration.

More than ever it is essential to examine the capabilities of the engineers and men, and allocate them to the work they can do best. Directions should be clear and concise, without any attempt to be too exact in detail. When incident reports come in, there should not be too much arranging in the office of what should be done to get things right. The engineer should naturally receive as much help as possible, but be left to decide what shall be done when he has examined the actual area of damage. It should always be remembered that messages about other incidents may not have got through, perhaps because of the failure of communications, delay in transmission of messages, or even injuries among the civil-defense personnel.

Assistance from the office should not only include technical advice, and suggestions about possible rearrangements of the networks, but also the organization of the supply of material to the site, in sufficient quantities, at the time it is wanted. These remarks naturally apply mainly to the distribution system, though they are also applicable to the consumer's departments. At the generating station, the executive staff can examine the damage for itself, but even here the charge engineer on duty must be allowed scope to make his own decisions, depending upon plant conditions and the effects of the night's bombing on the feeders and other equipment.

If time and conditions permit, it is a good plan to discuss the remedial measures taken on the various troubles, with a view to perfecting present arrangements and improving service in the future. But on no account should there be even a hint of inquisitional examination of the staff about their behavior, or suggestions that they could have done differently and better. It is always so easy to criticize after the event, when the raid is over and supplies are restored again, and when all the facts are known in the light of further knowledge.

It should be remembered that not only is it uneconomical to the undertaking to keep men standing idle, but nothing is so discouraging to both engineers and men who are doing their best, under far from ideal conditions, to think that the supply authority cannot bestir itself sufficiently to keep them going at their jobs. Idleness should be a crime in these times, but men may be forced to stop work if the undertaking fails to keep them supplied with material, information, and not least of all, decent food. It is worth remembering that bombing often makes the obtaining of meals very difficult out on the job, and preparations should be made to cater for this.

Finally, it should be put on record that while electricity-supply engineers do not boast about their achievements, they do realize that they are an important adjunct to the successful prosecution of the war. By their ingenuity and resource, and by their refusal to be shackled with the usual routine methods and traditions, they perform the important duty of meeting all demands made upon them by wartime conditions.

Railroad Electrification in Brazil

Electrification of 207 track-miles of the meter-gauge Sorocabanca Railroad, owned by the state of Sao Paulo, Brazil, is now in progress, with equipment purchased in the United States. Work on the $10,000,000 project, which is being handled by a Brazilian construction firm, is expected to be completed in about three years.

The section being electrified is a double-track main line from the industrial city of Sao Paulo west to Santa Antonio, over mountainous terrain with many curves and two-per-cent grades. Heavier rails are being laid. To replace the 80-ton steam locomotives now in service, 20 3,000-volt d-c 130-metric-ton electric locomotives are being built, 10 of them entirely by the General Electric Company, the others with electric equipment made by the Westinghouse Electric and Manufacturing Company and mechanical parts by General Electric.

Of the most powerful narrow-gauge type of construction available to date, these locomotives make possible the use of heavier trains at higher speeds. They are designed for both passenger and freight service. For suburban service around Sao Paulo, four three-car multiple-unit trains are being supplied. Freight includes industrial products carried westward, and coffee, sugar, and agricultural products carried eastward, much of it for export.

Hydroelectric power for the railroad will be supplied through three substations, each to be equipped with three 2,000-kw 3,000-volt mercury-arc rectifiers and transformers. Guyed concrete poles made of Brazilian cement will support the overhead wire system, except in urban areas where steel poles and bridges will be used.

The electrification not only will enable the railroad to handle increasing traffic, but will solve a serious fuel problem. Brazil has little coal or petroleum, and the use of wood as fuel for locomotives has been diminishing the forests at a rapid rate.

The Sorocabanca electrification was the subject of a recent forum held by the transportation group of the AIEE New York Section.

The Second Mile

WILLIAM E. WICKENDEN
FELLOW AIEE

Every calling has its mile of compulsion, but beyond that lies a mile of voluntary effort, where men strive for excellence, give unrequited service to the common good, and seek to invest their work with a wide and enduring significance, says this prominent educator, who adds that six-year college courses and licensing, although perhaps good as far as they go, cover only the first mile; beyond lies "a second mile of growth and advancement for which effective stimuli, incentives, and rewards can be provided only within the profession itself."

"WHOSOEVER shall compel thee to go one mile—go with him twain." You will recognize this text from the Sermon on the Mount as a counsel of perfection, good advice in paradoxical form which emphasizes a profound truth by an apparent denial of common sense. A preacher who was once reproached for straying rather far from his text replied: "A text is like a gate; it has two uses—you can either swing on it, or open it and pass through." Let us swing a moment, then pass on through. Every calling has its mile of compulsion, its daily round of tasks and duties, its standard of honest craftsmanship, its code of man-to-man relations, which one must cover if he is to survive. Beyond that lies the mile of voluntary effort, where men strive for excellence, give unrequited service to the common good, and seek to invest their work with a wide and enduring significance. It is only in this second mile that a calling may attain to the dignity and the distinction of a profession.

There is a school of thought which seems to hold that all the problems of the engineering profession lie in the mile of compulsion. They hope to solve most of them by giving the profession a legal status. You may hear them saying "If only we compel all who would bear the name engineer to go the mile which ends in a professional examination and a public license, we shall have protection, prestige, and profit to our heart's desires." They forget, perhaps, that there are many useful callings which have traversed this mile without finding the higher professional dignities at its end. We license embalmers, chiropodists, barbers, and cosmetologists, but we do it for the protection of the public, and not to erect them into castes of special dignity and privilege.

IS NOT EVERY OCCUPATION A PROFESSION?

There seems to be an illusion abroad that any calling may claim recognition as a profession by merely willing it so and by serving notice to that effect on the rest of the world. It is supposed to help a lot, too if you can invent for your occupation some mysterious-sounding name derived from the Greek. One reads, for example, of a group of barbers who elect to be known hereafter as "chirotonsors," in order to raise the prestige of their "profession." Why not, when you have cosmetologists right in the same shop? The truth seems to be that as soon as any word acquires a halo of distinction, every one wants to claim it, and the unique value of the word is quickly destroyed by indiscriminate usage. When one scientist observed what the advertising fraternity has done to the word "research," he remarked dryly that we now use that word to mean so many things we shall soon have to invent another word to mean research. The ambition to dignify honorable work is laudable, but there is much seizing after the form and letting the substance escape, which would be ludicrous if it were not pathetic.

A prominent English churchman once remarked jokingly that there were three sorts of Anglicans: the low and lazy, the broad and hazy, and the high and crazy. It seems to be much the same among engineers in our thinking about our profession. We have a low church party, indifferent to forms and organizations, which holds that status and titles are of little consequence; so long as the public allows us to claim them not much else matters if the engineer does an honest day's work. The broad church party is all for inclusiveness; if business men and industrialists wish to call themselves engineers, let us take them in and do them good, not forgetting the more expensive grades of membership. The high church party is all out for exclusive definitions and a strictly regulated legal status; in their eyes, what marks a man as a "professional" engineer is not his learning, his skill, his ideals, his public leadership—it is his license certificate.

WHAT PROFESSIONS HAVE IN COMMON

In view of these divided counsels, it may not be amiss to consider briefly what a profession is, how it came to be, why it exists, how its status and privileges are maintained and what obligations it entails; and finally to discuss a few of our current issues in the light of these backgrounds.

Of professions there are many kinds: open professions like music, to which any man may aspire within the bounds of his talents, and closed professions like medicine

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This article presents the essential substance of an address delivered by Doctor Wickenden before the Engineering Institute of Canada at Hamilton, Ont., February 7, 1941, and elsewhere, brought up to date and especially arranged for publication.

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which may be entered only through a legally prescribed process; individual professions like painting and group professions like law, whose members constitute "the bar," a special class in society; private professions like authorship and public professions like journalism; artistic professions like sculpture and technical professions like surgery; ameliorative professions like the ministry and social work and professions which achieve their ends by systematic destruction like the army and navy. Despite all these differences of pattern, there are characteristic threads which run like a common warp beneath the the varying woof of every type of professional life and endeavor.

If one seeks definitions from various authorities, he finds four characteristic viewpoints. One authority will hold that it is all an *attitude of mind*, that any man in any honorable calling can make his work professional through an altruistic motive. A second may hold that what matters is a certain *kind of work*, the individual practice of some science or art on an elevated intellectual plane which has come to be regarded conventionally as professional. A third may say that it is a special *order in society*, a group of persons set apart and specially charged with a distinctive social function, as the bar, the bench and the clergy. Still others would insist that no work can properly be called professional unless it involves a *confidential relationship* between an agent and a client, like that of a physician to his patient, an attorney to the party he represents, a minister to a penitent making confession, or a social worker to a person or family seeking rehabilitation.

To sum up the sources of confusion, some define a profession solely in terms of ideals professed, others solely in terms of practices observed, and still others in terms of legal powers exercised. None the less, there is a considerable area of agreement. All authorities recognize that some of the distinguishing attributes of a profession pertain to individuals, while others pertain to groups, but there is considerable variation in the emphasis given. Let us glance briefly at these two sorts of distinguishing attributes.

MARKS OF THE PROFESSIONAL MAN AND GROUP

What marks off the life of an individual as professional? First, I think we may say that it is a *type of activity* which is marked by high individual responsibility and which deals with problems on a distinctly intellectual plane. Second, we may say that it is a *motive of service*, as distinct from profit. Third, is the *motive of self-expression*, which implies a joy and pride in one's work and a self-imposed standard of workmanship—one's best. And fourth, is a *conscious recognition of social duty* to be accomplished, among other means, by guarding the standards and ideals of one's profession and advancing it in public understanding and esteem, by sharing advances in professional knowledge, and by rendering gratuitous public service, in addition to that for ordinary compensation, as a return to society for special advantages of education and status.

Next, what are the attributes of a group of persons which mark off their corporate life as professional in character? I think we may place first a *body of knowledge* (science) *and of art* (skill), held as a common possession and to be extended by united effort. Next we may place *an educational process* of distinctive aims and standards, in ordering which the professional group has a recognized responsibility. Third in order is a *standard of qualifications*, based on character, training, and competency, for admission to the professional group. Next follows a *standard of conduct* based on courtesy, honor, and ethics, to guide the practitioner in his relations with clients, colleagues, and the public. Fifth, I should place a more or less formal *recognition of status* by one's colleagues or by the state, as a basis of good standing. And finally *an organization* of the professional group devoted to its common advancement and social duty rather than the maintenance of an economic monopoly.

HOW PROFESSIONS CAME TO BE

The traditional professions of law, medicine, and divinity had a common fountainhead in the priestcraft of antiquity. What is professional in engineering and in certain other modern callings can be traced back only so far as the medieval merchant and craft guilds. The guilds arose in the period when feudal society was breaking down, but before strong central and local governments had been created. There was a gap which only voluntary organizations could fill. In this disorganized period men who wished to engage in far-flung commerce, with no strong state to protect them by its army or navy, had to band together for their own protection, as did the merchants of the Hanseatic League along the shores of the Baltic Sea.

The various crafts likewise found it necessary to organize guilds for mutual protection and regulation, and this in turn led to monopolistic control. In the various crafts it was the guilds which regulated by ordinance the hours of labor, the observance of holidays, the length and character of apprenticeship, and the quality of workmanship; and it was the guild which tested the progress of novices, apprentices, and journeymen and finally admitted them to the ranks of the masters.

When the cities and the states waxed powerful, they usually confirmed the monopolies which the guilds had gathered to themselves and even incorporated them into the structure of the municipality, as in the City and Guilds of London. The church too lent its blessing, since the religious philosophy of the middle ages regarded society as a commonwealth divided into divinely ordained functions, and not as a mere aggregation of individuals—an idea which recent Papal encyclicals have sought to reanimate under the name of a corporative society. In the spirit of the times, the guilds required members to contribute periodically to a common fund for the relief

of distress, to participate in certain religious observances, and to honor certain festivities and pageants.

PROFESSIONAL LIFE A FORM OF CITIZENSHIP

Guild life was a highly developed form of citizenship, centered around occupations rather than politics. If you have an opportunity to see a performance of Richard Wagner's opera "Die Meistersinger," you will not only hear much magnificent music, but see an unforgettable picture of guild life in its medieval home. Many of the features of this unique form of citizenship are perpetuated in our modern professional bodies. The public grants to a profession more or less tangible monopolies and self-governing privileges, in consideration of which it engages to admit to its ranks only men who have proved their competency, to scrutinize the quality of their work, to insist on the observance of ethical relations, and to protect the public against extortion and bungling.

The occasion which calls for professional service is often a human emergency in which the legal doctrine of *caveat emptor*—let the buyer beware—breaks down. When a baby is about to be born or an appendix must be removed, you do not want to drive a smart bargain at your own risk, but you do want some credentials to assure you that the job is in competent hands. When a layman comes face to face with the complex and often terrifying specialization of professional knowledge and skill, he is likely to be baffled or even misled. If you have a problem of mental hygiene in your family, how can you be sure you are dealing with a qualified psychiatrist and not with a plausible but unscrupulous quack? To protect you in these emergencies, the public wisely puts the burden of guaranteeing at least minimum standards of competence and ethics on the profession itself. The physician you can trust is the one who is recognized to be well qualified and reputable by other physicians of good standing; the same with lawyers, dentists, architects, and engineers.

The public may implement this obligation which it places on the profession by appointing a board from its members to conduct professional examinations and to issue licenses to those who pass them successfully, or it may leave the profession free to issue its own credentials, as the actuaries do; but in the end it comes down to the same thing—a profession must guarantee to the public the competency of its practitioners. In return, the public protects the profession from the incompetent judgment of the layman by a privileged status before the law.

PROFESSIONAL DUTY TO SOCIETY

Professional status is therefore an implied contract to serve society, over and beyond all duty to client or employer, in consideration of the privileges and protection society extends to the profession. The possession and practice of a high order of skill do not in themselves make an individual a professional man. Technical training pure and simple, I think we can agree, is vocational rather than professional in its character. The difference between technical training and professional education is not merely a matter of length—of two years, or four, or six; nor is it a difference of intellectual levels. It is rather a matter of spirit and ideals, and even more a matter of what may be called an overplus beyond the knowledge a man needs to master his daily job. A surgeon, for example, may have to be extremely skillful in tying knots, which he learns by technical training and prolonged practice, but the overplus of his education which makes him a professional man consists largely of studies in biology and psychology which give him a deeper insight into the human organism and its hidden forces than he may ever require for the mastery of the most complex technique of his art. Professional education for the lawyer means more than training him to draw contracts or deeds, or wills, to make briefs or to try cases. It means also the study of history, philosophy, and social institutions out of which the law has grown as a deposit from man's age-long experience. Likewise for the engineer, professional education means not only skill in applying mathematics and the physical sciences, but also philosophic insights into these sciences as modes of human experience.

This overplus, again, involves a knowledge of social forces and institutions which will enable a professional man to view his work and its consequences not only as a service to a client, but also in terms of its implications for society. An engineer, for example, recommends the introduction of a labor-saving process; does he see in this only a saving in the immediate cost of production, merely assuming that this is a desirable end in itself, or can he perceive the sequence of effects which will be felt in the lives of individuals, the organization which employs them, the community in which it functions, and the wider sector of society which it serves? In the answer to this question there is wrapped up much of the difference between a high-grade technician and a man of true professional stature.

PROFESSIONAL MANAGEMENT IN INDUSTRY

Through all professional relations there runs a threefold thread of accountability—to clients, to colleagues, and to the public. Is business a profession or can it be made so? We sometimes hear it referred to as the oldest of trades and the newest of professions. It seems clear that business is moving away from the dog-eat-dog area to one nearer the fringe of professional life. This occurs whenever the direct administration of an enterprise passes out of the hands of owners who merely divide its profits, into the hands of managers who receive salaries for their services and who are expected to serve not their own interests, but the interests of others. Business may still be far from a true profession, but management is well within the pale. Business has lived traditionally from balance-sheet to balance-sheet; the time-span of its thinking has often been about three months;

the profit-and-loss statement has been its only yardstick. Professional managers, if assured of reasonable security of tenure, are better able to think and plan in terms of long-range prosperity and to act as responsible middlemen between investors, workers, customers, and the public. At one time I worked for the Bell Telephone System, of which no individual owns as much as one per cent. It is the best example of manager-operated, as distinct from owner-operated, business that I know of and the one that comes nearest to fulfilling professional standards.

All of us can take pride in this example, because it is so largely an engineer-managed enterprise. If we engineers were to narrow our professional fellowship so as to include only men who render technical service on an individual agent-and-client basis and exclude all whose work is primarily administrative, I feel that we should do an irreparable injury both to ourselves and to society. The engineer has been the pioneer in the professionalizing of industry, and his task is only begun. Organized labor, it seems, is intent upon gaining a larger voice in the councils of industry; it wants to sit in when policies are made and to share in planning the schedules of production.

Many labor organizations not only exercise a direct voice in management, but are also in a position to accumulate immense surplus funds from fees and dues. These funds may become one of the major sources of capital for investment in industry, making labor an important stockholder as well. If any such day is ahead, the middle-man of management who can reconcile the stake of the investor, the worker, the customer, and the public is going to be the key man on the team. For that responsibility, the finger of destiny points to the engineer. This makes it all the more urgent that the young engineer, while using every opportunity to gain a discriminating and even a sympathetic knowledge of the labor movement, should avoid being sucked into it by the lure of a quick gain in income and in bargaining power.

ETHICAL OBLIGATIONS

The ethical obligations of a profession are usually embodied in codes and enforced by police powers. The physician and lawyer are bound by explicit obligations, and woe betide the man who oversteps them. If the courts do not deal with him, the organized profession will. He must not only keep inviolate information confided to him by his client, serve his client's interest exclusively, and stay within strict bounds of procedure, but he must also observe definite rules in his relations with other members of his profession. As engineers, our codes are more intangible, as our duties are less definable, but our ethical obligations are no less severe.

In any case, the obligations of a profession are so largely matters of attitude that codes and police powers alone do not suffice to sustain them. Equal importance attaches to the state of mind known as professional spirit, which results from associating together men of superior type, and from their common adherence to an ideal, which puts service above gain, excellence above quantity, self-expression above pecuniary incentives, and loyalty above individual advantage. No professional man can evade the duty to contribute to the advancement of his group. His skill he rightly holds as a personal possession, and when he imparts it to another he rightly expects a due reward in money or service. His knowledge, however, is to be regarded as part of a common fund built up over the generations, an inheritance which he freely shares and to which he is obligated to add; hence the duty to publish the fruits of research and to share the advances in professional practice. If the individual lacks the ability to make such contributions personally, the least he can do to pay his debt is to join with others in creating common agencies to increase, disseminate, and preserve professional knowledge and to contribute regularly to their support. That is the purpose to which a large share of the membership dues of our professional societies is devoted.

There are too many engineers with a narrow and petty attitude on these matters; mature men who complain that the immediate, bread-and-butter value of the researches and publications of a professional society is not worth the membership fee, and young men who complain because it does not serve them as an agency of collective bargaining. Shame on us! Do we look with envy on the high prestige of medicine and of surgery? Then let us not forget that this prestige has been won not merely through personal skill and service, but through magnificent contributions to human knowledge without profit to the seekers and with incalculable benefits for all mankind. Do we covet public leadership on a par with the legal profession? Then we do well to remember that the overplus which differentiates a profession from a technical vocation calls for personal development and for powers of expression sufficient to fit a man for a place of influence in his community.

Measured by the standards I have been seeking to outline, many men who call themselves engineers and who are competent in accepted technical practices can scarcely be said to have attained a real professional stature. These are the men who have let their scientific training slip away after college days, who do not see beyond the immediate results of their work, who look on their jobs as an ordinary business relationship, who contribute nothing to advancement by individual or group effort, and who have little or no influence in society. They have been unable to surmount routine in the early stages of experience and have gradually grown content with mediocrity. There is much in the daily work of a physician, a lawyer, and a minister of religion which compels him to be a life-long student. In peacetimes the army officer is likely to spend one year in six going to school. The student habit is less often a mark of the engineer, which is natural perhaps in a man of action

rather than one of reflection, but far too many seem to leave all growth after their college days to the assimilation of ordinary experience, without deliberate intellectual discipline of any kind.

WHY NOT REQUIRE A LONGER TRAINING?

There is a certain school of thought which has two quick and ready remedies for all ills and shortcomings of the profession. One is to keep the boys longer in college and to compel them to cover both the arts and the engineering courses; the second is to compel every engineer to take out a public license. One need not quarrel with either the aims or the means; so far as they go both are good, but they cover only the first mile. Registration, I believe, will always be a qualifying standard rather than a par standard for the engineering profession. It will go far toward keeping the wrong men out, but will serve only indirectly to get the right men in. Beyond it lies a second mile of growth and advancement for which effective stimuli, incentives, and rewards can be provided only within the profession itself.

The riper experience of the medical profession seems a safe guide. For the protection of the public, the law determines who may practice general medicine; but if a registered physician wishes to qualify as an orthopedic surgeon, he submits to a training prescribed by a voluntary group of specialists and undergoes an examination at their hands rather than those of a public licensing board. Evidences of distinction are likewise a gift within the sphere of the profession's inner life, rather than the domain of law.

The proposal to compel all engineering students to remain six years or more in college in order to take degrees both in liberal arts and in engineering is attractive in theory but unworkable in practice. Some young men should do so, but the majority will not. No such plan can be made compulsory so long as engineering work covers so wide a range of responsibility and is available on attractive terms to four-year graduates, or so long as the typical student engineer shows unmistakable signs of growing fed up for the moment with formal teaching and study and of craving for action as graduation approaches.

All our experience suggests that the further possibilities in the mile of voluntary advancement are much more hopeful than those in a lengthened mile of compulsory discipline. Growth in voluntary postgraduate enrollments has been going forward at a truly surprising pace. The ratio of master's degrees to bachelor's degrees granted in our engineering schools has passed one to ten and that of doctorates is close to one in a hundred. Especially important is the fact that so many of these advanced students have discovered needs and tastes for further study in their early professional experience and are now going forward with a strong individual purpose and not merely as passengers on an academic conveyor.

Equally encouraging are the gains in liberalizing the engineering curriculum by more adequate inclusion of studies in language and literature, in history and economics, and in psychology and social institutions—gains which are being made possible by the progressive transfer of specialized technical studies to the graduate plane. My enthusiasm is stirred by the rapid gain in cultural interest and activity among engineering students, gains in the reading of books, in attendance at the theater, in hearing and producing music, and in artistic forms of expression.

One cannot urge too strongly on a group of student engineers the necessity of extending and broadening their education in the second mile of voluntary effort beyond graduation. The graduate may feel assured of his ability to secure employment, to do useful work, and to earn his keep. This may seem like quite an advantage over the arts graduate, but is it enough? The mere fact of graduation will not guarantee much more. It is not a badge of distinction; about one young man in every six in our entire population now goes to college, and one in every fifteen is likely to hold a degree. It is not a guarantee of preferment; why engineering graduates without further training so often complain of supposed economic neglect in so competitive a field is a mystery to me. It does not entitle a man to professional consideration; the graduate is a novice with his professional spurs yet to win.

It is true enough that not a few engineering graduates are building useful and sometimes successful careers by simply doing each day's work, assimilating its experience, and seizing its opportunities, without benefit of sustained study. Well and good, but these are not rightly classed as professional careers. They are business or industrial careers, and usually narrow ones at that. No one can quarrel with them, but we are concerned now with the future of the engineering profession, with men who cannot only produce technical results and business profits, but who can be looked to for the advancement of knowledge, for the development of improved methods and products; men who can be trusted with confidential problems, with conflicting interests, and with the general welfare; men who can contribute to our common culture as well as our material comfort and convenience; and men who can shape the policies which are to guide society as well as the tools to defend and equip it. Leadership in engineering, as in law, medicine, architecture, and religion is for men who can combine boldness in action with lifelong habits of study.

A LOOK AHEAD

Let us risk a look into the next 50 years, which our present student engineers are to share in shaping. The climax of man's effort to subdue nature, to shift labor from muscles to machines, to make material abundance available to all, and to extend a high civilization into the backward areas of the world may well fall within their lifetime. After that, perhaps human interest may shift from work to leisure, from production to enjoy-

ment, from economic progress to culture and from industry to art. Who knows? In the meantime, however, it seems inevitable that industry will be extended on world-wide lines, production will grow more scientific, research will expand, and engineers will multiply accordingly.

Engineers will find their way into every field where science needs to be practically applied, cost counted, returns predicted, and work organized systematically. They will be called upon to share the control of disease with physicians, the control of finance with bankers, the bearing of risks with underwriters, the organizing of distribution with merchants and purchasing agents, the supplying of food with packers and purveyors, the raising of food with farmers, and the operation of the home with housewives. In few of these new fields, if any, will engineers be self-sufficient; to be useful they must be teamworkers; and they must be prepared to deal with "men and their ways," no less than "things and their forces."

The engineering profession, it seems equally evident, will bear much heavier responsibilities in civic and economic affairs. It cannot afford to become either a narrow caste of highly skilled technicians or a free-for-all alumni association of engineering graduates. It will probably never be able to define its boundaries precisely, nor become exclusively a legal caste, nor fix a uniform code of educational qualifications. Its leaders will receive higher rewards and wider acclaim. The rank and file will probably multiply more rapidly than the elite, and rise in the economic scale to only a moderate degree.

WHAT IF TECHNOLOGICAL EDUCATION BECOMES DOMINANT?

Technological education, now being pushed into greater prominence by the defense crisis, may find itself taking on a permanently dominant role. To fulfill any such function, it must break away from its present conventional uniformity. At one extreme, a part of it must become more profoundly scientific; at the other extreme, a vast development of practical technical education for directing production will be in demand. Engineering schools ought to be less alike, less standardized by imitation. The men who are to lead the profession will need a longer training, and one that is both more broadly humanistic and more profoundly scientific. Great numbers of workers in technology could do well with a more intensive type of training. For every *one* who should receive post-graduate training, possibly *four* would find the present course sufficient, and *ten* would find an intensive two-year course more suitable. The science of economy needs to be more strongly emphasized at all levels. A science of human work needs to be created and systematically taught.

The engineer's job will be so varied, and will change so fast, and his tools will so increase in variety and refinement with the advance of science, that no engineer can hope to get a once-and-for-all education in advance. We must expect to re-educate engineers at intervals throughout their careers. The most important development of all may come in after-college education. In the future we shall see large numbers of young engineers coming back to college, some for full time, some for half time, some in the evening, some in correspondence divisions; some to pursue higher work in science, some for new engineering technique, some for training in economics and business, and not a few for broader cultural opportunities. This is as it should be. We should cease to think of education as a juvenile episode. Once these means of adult education are provided in ample degree, the engineering colleges could broaden the scientific and humanistic bases of their curricula, cut down on early specialization, relieve overcrowding, inspire independent work, and show the world the best balanced and best integrated of all modern disciplines.

COMPETENCE AND CULTURE

There are undoubtedly some who feel that the cultural and spiritual interests of society are menaced by a greater dominance of technological education. I am unable to share these fears. We of the engineering schools have no quarrel with liberal education. We recognize that there are great numbers of young people whose career purposes come to a focus late rather than early in adolescence and who do well to lay first their foundations of culture and social understanding before attempting to build up some special competence. We believe, however, that there are a great many more young people than are now provided for whose career aims can be brought to a focus late in the secondary period and who will do best to lay first the foundations of competence, then to erect on them a superstructure of social understanding and personal participation in cultural activity. If we were to criticize the traditional emphasis of the liberal arts, we should do so on the ground that the preservation and advancement of culture and social ideals, except for certain highly trained specialists, are not the obligation of a special elite in today's society, but one which rests equally on men and women in all occupations and social groups.

We are not indifferent to culture, save that of the dilettante type. Culture is to us not a form of professional interest, nor the fruit of any form of pose or academic exposure, but the fruit of spontaneous activity which all may share on an amateur basis in that second mile which lies beyond the compulsions of one's economic occupation. Expressional activities—sport, music, writing, speaking, dramatics, and the arts of design—also the reading of books, are flourishing on many an engineering campus today quite as vigorously as in many a so-called liberal college. If destiny is to make our technological institutions responsible in the future for a major stem of higher education, and not merely for some of its specialized phases, I have faith that we shall give a good account of our stewardship.

Analysis of Systems With Known Transmission-Frequency Characteristics by Fourier Integrals

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During the winter of 1940–41 the basic science group of the AIEE New York Section held a symposium on "Advanced Mathematics as Applied to Electrical Engineering." This is the fourth lecture of the series. The three preceding lectures are listed as the first three references at the end of this article. Any reader who is not familiar with integration in the complex plane should study the second article of the series before attempting the material that follows. The Fourier integral, discussed in this article, is one of the most important mathematical contributions of all time. It is of great general significance, and may be used as a basis in deriving the Laplace transforms, both the direct transform and the inverse transform or Bromwich integral.

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LINEAR SYSTEMS in the general transient state may be analyzed effectively by means of the operational calculus, the Laplace transforms, or the Fourier transforms. Preceding articles in this series have introduced the operational calculus,[1] the Laplace transforms,[3] and certain essential mathematical ideas and processes pertaining to the manipulation of functions of a complex variable.[2] The emphasis thus far has been on the analysis of systems involving known configurations of concentrated elements (resistance, inductance, and capacitance).

The Fourier integral and its transforms, as well as the operational calculus and the Laplace transforms, may be used to analyze such systems. As the complexity of a system increases, that is, as the number of meshes (or the number of stages in an amplifier, for example) increases, the labor of evaluating the operators or transforms increases greatly, whether partial fractions are used, or evaluation by means of poles and residues. Furthermore, the expression for the response may contain so many functions that plotting the curve of this response is likely to be laborious. Finally, it may be desirable to determine the transient response of an entire radio system from the output of the microphone, or television camera tube, for example, to the input of the receiver loud-speaker, or picture tube. The transient response of complex systems such as filters, selective networks, and even entire radio systems may be found by a method using the Fourier transforms and the a-c steady-state transmission-frequency characteristics of the systems. It is the purpose of this article to describe this application of the Fourier transforms.

TRANSMISSION-FREQUENCY CHARACTERISTICS

Let a linear system be subjected to a perturbing force that varies sinusoidally with respect to time. In the a-c sinusoidal steady state, all currents and voltages in the system will vary sinusoidally with time at the same frequency as that of the perturbing force. Suppose that the perturbing force is a voltage e_1, impressed between two terminals of the system, and that e_2 is the voltage between two other terminals (Figure 1). Then

$$e_1=E_1 \cos (\omega t+\phi_1)$$

and $$e_2=E_2 \cos (\omega t+\phi_2)$$

where E_1 and E_2 are the respective maximum values, ϕ_1 and ϕ_2 are the respective phase angles, and $\omega=2\pi f$ is the radian frequency. In general

$$E_2=A(\omega)E_1$$

and

$$\phi_2=\phi_1-\theta(\omega)$$

where $A(\omega)$ is the amplitude factor linking E_2 and E_1, and $\theta(\omega)$ is the phase angle by which e_2 lags e_1 (both are functions of frequency as indicated). Using complex quantities to represent the voltages:

$$\boldsymbol{E}_1=E_1\epsilon^{j\phi_1}$$

$$\boldsymbol{E}_2=E_2\epsilon^{j\phi_2}=\boldsymbol{A}(\omega)\boldsymbol{E}_1$$

where

$$\boldsymbol{A}(\omega)=A(\omega)\epsilon^{-j\theta(\omega)}$$

Thus $\boldsymbol{A}(\omega)$ is the complex transmission-frequency function linking $\boldsymbol{E}_2$ and $\boldsymbol{E}_1$; $A(\omega)$ is the amplitude function, and $\theta(\omega)$ is the phase function.

The voltage between any two points, as well as any current in the system, is linked with $\boldsymbol{E}_1$ by its respective transmission-frequency function. In the case of a current, $\boldsymbol{A}(\omega)$ is the complex transfer (or driving-point) admittance function.

In general, $A(\omega)$ is an even function of ω, and $\theta(\omega)$ is

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an odd function (Figure 1). If these curves are available, the steady-state response to any combination of sinusoidal perturbing forces may be found by superposition. The transient response, also, may be computed if these functions are known. For very simple systems it may be possible to obtain analytical expressions for the transmission-frequency functions $A(\omega)$ and $\theta(\omega)$. For more complex systems, curves of the functions may be found by computation or by direct measurement.[18] For certain systems (such as selective networks) it may be feasible arbitrarily to assume idealized over-all characteristics. As an example, it is useful for some purposes to assume straight-line characteristics for the idealized low-pass system illustrated in Figure 2. For this case (for values of ω between $-\omega_A$ and ω_A),

$$A(\omega)=1$$
$$\theta(\omega)=\omega t_d$$
$$\mathbf{A}(\omega)=\epsilon^{-j\omega t_d}$$

The constant slope of the phase characteristic, t_d, is identified hereinafter as a delay time. The independent assumption of arbitrary amplitude and phase characteristics may lead to certain physical inconsistencies. In fact, in minimum-phase-shift networks, $A(\omega)$ and $\theta(\omega)$ are definitely connected by a functional relation, as shown by Bode.[19] An interesting physical interpretation of this interdependence may be found in a paper by Wheeler.[20]

THE FOURIER SERIES

The Fourier series furnishes a powerful method of obtaining an analytical expression for a function between two arbitrary values of the independent variable (it automatically gives periodic repetitions of the function outside these bounds, however). The Fourier series is particularly useful in that it will apply to functions having a finite number of discontinuities within the bounds. If a function is naturally periodic, the Fourier series will

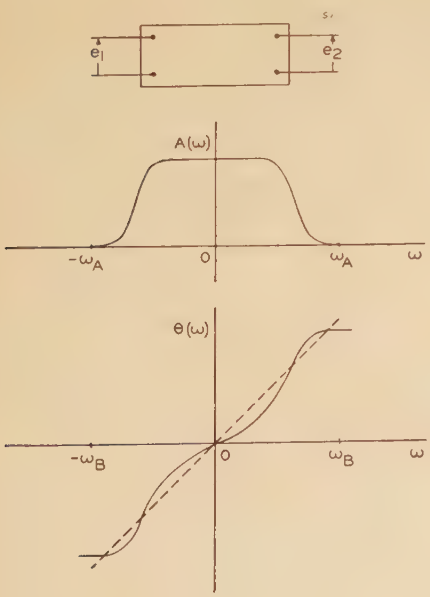
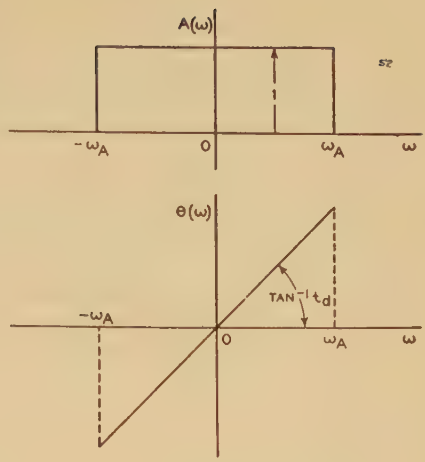


Figure 1. Over-all amplitude and phase transmission-frequency functions of a system

Figure 2. Idealized characteristics of a low-pass system



give an analytical expression valid for all values of the independent variable. The trigonometric form for the series is:

$$e_1=\frac{E_0}{2}+\sum_{n=1,2,3\ldots}^{\infty} E_n \cos(n\omega_1 t+\phi_n) \tag{1}$$

where e_1 is a periodic perturbing force (for example), E_n is the amplitude and ϕ_n is the phase angle of the nth harmonic component, $E_0/2$ is the average value (or d-c component), $\omega_1=2\pi/T$ is the radian frequency of the fundamental, $n\omega_1$ is the radian frequency of the nth harmonic component, and T is the period (in seconds). When the function may be defined, throughout the duration of a period, by combinations of analytical expressions, E_n and ϕ_n may be computed in the usual manner. When the function lacks any special symmetries, the exponential form of the series will be found to be very useful. Furthermore, the exponential form is very compact and may be used effectively in many problems.[4] It may be derived from the trigonometric form of the series by using the following device:

$$\cos(n\omega_1 t+\phi_n)={}^1/_2\epsilon^{j(n\omega_1 t+\phi_n)}+{}^1/_2\epsilon^{-j(n\omega_1 t+\phi_n)}$$

Then

$$e_1=\frac{1}{2}\sum_{-\infty}^{\infty}\mathbf{E}_n\epsilon^{jn\omega_1 t} \tag{2}$$

where n assumes all integer values both positive and negative, as well as zero, and

$$\mathbf{E}_n=E_n\epsilon^{j\phi_n}=\frac{2}{T}\int_{-T/2}^{T/2}\epsilon^{-jn\omega_1 t}e_1(t)dt \tag{3}$$

Thus the complex coefficient $\mathbf{E}_n$ contains both the amplitude and the phase of the nth harmonic component. For details of the derivation consult reference 4.

The use of the Fourier series in a-c steady-state analysis is well-known. If a periodic, but nonsinusoidal, perturbing force is impressed on a linear system, the perturbing force is resolved into a sum of sinusoidal components by means of the Fourier series. Each component is modified by the proper transmission-frequency

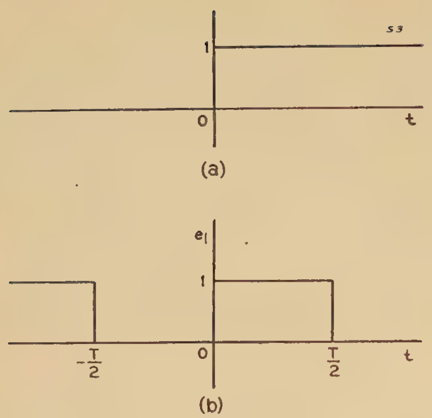


Figure 3. The unit step function and its corresponding periodic function, the rectangular wave

function to give the corresponding response. The complete response consists of the superposition of the various component responses. Thus if e_1 is the perturbing force, and

$$\boldsymbol{A}(n\omega_1)=A(n\omega_1)\epsilon^{-j\theta(n\omega_1)}$$

is the transmission-frequency function, then the response will be

$$e_2=\frac{1}{2}\sum_{-\infty}^{\infty}\boldsymbol{A}(n\omega_1)\boldsymbol{E}_n\epsilon^{jn\omega_1 t} \tag{4}$$

where $\boldsymbol{E}_n$ is given by equation 3. The trigonometric form for the response is

$$e_2=\frac{1}{2}A(0)E_0+\sum_{n=1,2,3\ldots}^{\infty}A(n\omega_1)E_n\cos\left[n\omega_1 t+\phi_n-\theta(n\omega_1)\right] \tag{5}$$

In order to obtain the actual curve of the response, it is necessary to add the values of the components for each assumed value of time.

Systems involved in the transmission of sound and speech signals have been analyzed usually by means of a-c steady-state theory (including the Fourier series). Systems concerned with picture transmission or television, however, are subjected to perturbing forces that are neither sinusoidal nor periodic in general, but change abruptly in value in an irregular manner. Thus a scanning beam does not usually sweep over regions that vary periodically in brightness, but it may move quite suddenly from a dark region to a bright one. Distortion in such systems may be studied by subjecting them to perturbing forces that change suddenly, and examining the response for its fidelity of reproduction. Certain simple perturbing forces of this type are the unit impulse function, the unit step function, and the pulse function. The resolving power of such systems may be studied by impressing a succession of two or more pulses and observing how badly they merge together in the response. The transient response of complex systems, such as those involved in the transmission of pictures, may be found by means of the Fourier integral (as demonstrated hereinafter), or by means of the Fourier series, which is closely related to the Fourier integral.

Use of the Fourier series in determining the transient response of systems with known transmission-frequency characteristics is based upon the following reasoning:[5–7] Suppose that a system is subjected to one of the simple perturbing forces mentioned; after a certain time interval, which depends on the natural transient time duration (time constant) of the system, the transient response will have disappeared practically. If, after the elapse of this time, the system is again subjected to a similar perturbing force (possibly reversed in polarity), then a similar transient response will occur. In other words, a perturbing force consisting of a periodic repetition of a series of simple transient-type perturbing forces will produce a periodic succession of corresponding transient responses, provided the period of the perturbing force is sufficiently long compared with the natural time duration of the transient response of the system. The method is then quite simple—a Fourier analysis of the perturbing force, each term modified by its corresponding transmission-frequency function, and a synthesis (or superposition) of the corresponding terms in the response. As an example, consider the unit step function as a perturbing force (Figure 3a). The periodic (alternating) repetition of this function is the rectangular wave (Figure 3b). The Fourier series for the rectangular wave is

$$e_1=\frac{1}{2}+\frac{2}{\pi}\sum_{n=1,3,5\ldots}^{\infty}\frac{1}{n}\sin n\omega_1 t \tag{6}$$

$$=\frac{1}{2}+\frac{2}{\pi}\left[\sin\omega_1 t+\frac{1}{3}\sin 3\omega_1 t+\ldots\right]$$

The expression for the response is then

$$e_2=\frac{1}{2}A(0)+\frac{2}{\pi}\sum_{n=1,3,5\ldots}^{\infty}\frac{A(n\omega_1)}{n}\sin\left[n\omega_1 t-\theta(n\omega_1)\right] \tag{7}$$

Note that if $\theta(n\omega_1)=n\omega_1 t_d$ (ideal linear phase function),

$$\sin\left[n\omega_1 t-\theta(n\omega_1)\right]=\sin n\omega_1(t-t_d)$$

and each term of the response is delayed by the time t_d. If the rectangular wave is impressed on a low-pass system, the response will resemble the curve in Figure 4a (provided the period of the rectangular wave is suffi-

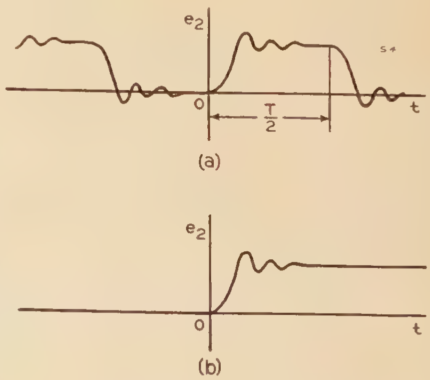


Figure 4. Response of a low-pass system to the rectangular wave, and the corresponding response to a step function

ciently long). The response to the unit step function is given by the portion of the curve shown in Figure 4b. An application of this method to the transient response of multistage video-frequency amplifiers may be found in reference 5. The method is useful in obtaining results experimentally,[8] and commercial square-wave generators are now available for testing purposes.

THE FOURIER INTEGRAL

The transient response of a system having known amplitude and phase transmission-frequency functions may be determined by means of the Fourier series, provided the number of terms in the series necessary for an accurate portrayal of the response is not unreasonably large. For systems having relatively long natural transient time durations, the period of the perturbing wave must be correspondingly great, and the labor of computation may become prohibitive.

The unit step function may be considered as the limit of the rectangular wave as the period approaches infinity. If this concept is applied mathematically an analytical expression for the unit step function will be found. Equation 6 may be written as

$$e_1=\frac{1}{2}+\frac{2}{\pi}\sum_{n=1,3,5\ldots}^{\infty}\frac{\sin n\omega_1 t}{n\omega_1}2\omega_1$$

$$=\frac{1}{2}+\frac{1}{\pi}\sum_{n=1,3,5\ldots}^{\infty}\frac{\sin \omega_n t}{\omega_n}\Delta\omega$$

where

$$\omega_n=n\omega_1$$
$$\Delta\omega=2\omega_1$$

The significance of the summation is apparent from a study of Figure 5, which is a plot of the amplitude line spectrum for the harmonic components of the rectangular wave. As the period of the wave is allowed to approach infinity, the frequency ω_1 of the fundamental component approaches a differentially small value ($\omega_1=2\pi/T$); thus $\Delta\omega$ approaches $d\omega$, and the summation becomes an integration. The procedure is similar to that used in the calculus to obtain the expression for an area as an integral, which is the limit of a sum of incremental areas. The result is the Fourier integral expression for the unit step function.

$$e_1=\frac{1}{2}+\frac{1}{\pi}\int_0^{\infty}\frac{\sin \omega t}{\omega}d\omega \tag{8}$$

Since ω now varies continuously from zero to infinity, the amplitude spectrum is a continuous one. If equation 7 is treated in the same manner, the Fourier integral for the response due to a step function is obtained:

$$e_2=\frac{1}{2}A(0)+\frac{1}{\pi}\int_0^{\infty}\frac{A(\omega)}{\omega}\sin\,[\omega t-\theta(\omega)]d\omega \tag{9}$$

The response of an idealized low-pass system to an impressed unit step function, for example, is found by inserting the expressions for the transmission-frequency functions (Figure 2) in equation 9. The result is

$$e_2=\frac{1}{2}+\frac{1}{\pi}\int_0^{\omega_A}\frac{\sin \omega(t-t_d)}{\omega}d\omega \tag{10}$$

This integral occurs frequently in analysis; it is called the sine-integral function. Tables of values are available.[9] A sketch is shown in Figure 6a. The following notation is used:

$$\text{Si } ax=\int_0^{ax}\frac{\sin m}{m}dm=\int_0^{a}\frac{\sin mx}{m}dm$$

Therefore

$$e_2=\frac{1}{2}+\frac{1}{\pi}\text{Si } \omega_A(t-t_d) \tag{10a}$$

A sketch of the response is given in Figure 6b; it is a distorted step function delayed by the time t_d. Leading ripples (echoes) may occur before $t=0$, due to the arbitrary assumption of independent amplitude and phase characteristics for the low-pass system. This matter is discussed in reference 10, pages 480 and 501–04 (see also references 19 and 20). As ω_A (the cutoff frequency) increases, the response resembles more closely the step function. Note that Si$(\infty)=\pi/2$ while Si$(-\infty)=-\pi/2$; if these values are inserted in equation 8, $e_1=1$ for $t>0$, and $e_1=0$ for $t<0$, the description of the unit step function.

Equation 9 gives the true response of any system to the unit step function provided $A(\omega)$ and $\theta(\omega)$ are known; it could be solved by graphical integration, for each assumed value of time, if $A(\omega)$ and $\theta(\omega)$ were given as curves, although this would be a very laborious task. Similar relations may be developed for other types of impressed perturbing forces. However, it is possible to derive the Fourier integral expression for a general arbitrary function, as well as the Fourier integral for the response due to this function. The method is the same as that used for the step function, except that the more compact exponential form of the Fourier series is used. Consider some general function $e_1(t)$ (Figure 7a); this function may be described by a Fourier series between definite bounds, but will be repeated periodically outside those bounds (Figure 7b). If equation 3 is substituted in equation 2, the general exponential form of the Fourier series for the function described in Figure 7b is obtained ($1/T$ is replaced by its equivalent $\omega_1/2\pi$).

$$e_1(t)=\frac{1}{2\pi}\sum_{-\infty}^{\infty}\epsilon^{jn\omega_1 t}\omega_1\int_{-T/2}^{T/2}\epsilon^{-jn\omega_1 t}e_1(t)dt$$

As before, let $n\omega_1=\omega_n$ and $\omega_1=\Delta\omega$ (since n may assume *all* integer values in general).

$$e_1(t)=\frac{1}{2\pi}\sum_{-\infty}^{\infty}\epsilon^{j\omega_n t}\Delta\omega\int_{-T/2}^{T/2}\epsilon^{-j\omega_n t}e_1(t)dt$$

In order to describe the original function (Figure 7a) more and more completely, the period T (Figure 7b) is

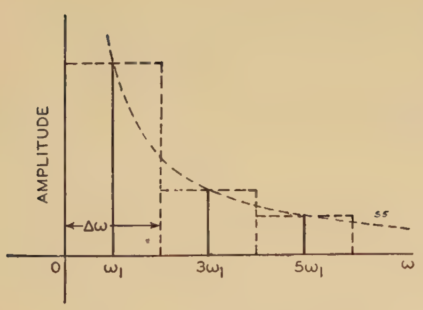


Figure 5. Amplitude line spectrum for the harmonic components of the rectangular wave

allowed to approach infinity. Then ω_1 approaches $d\omega$, and the summation becomes an integration.

$$e_1(t)=\frac{1}{2\pi}\int_{-\infty}^{\infty}\epsilon^{j\omega t}d\omega\int_{-\infty}^{\infty}\epsilon^{-j\omega t}e_1(t)dt \tag{11}$$

Equation 11 is the exponential form of the Fourier integral for a function $e_1(t)$ described throughout the entire range of its independent variable. Like the Taylor series, it is a general analytical expression for a function; unlike the Taylor series, it is valid for functions that are not continuous. It furnishes a single closed analytical expression for a function that may be composed of several pieces or sections of other functions. Various other forms of the Fourier integral are obtained from equation 11; by substituting $\omega=2\pi f$ the $1/2\pi$ factor is removed; by replacing the exponentials with their trigonometric equivalents ($\epsilon^{\pm jx}=\cos x\pm j\sin x$) the trigonometric forms are obtained.[11] Equation 11 may be considered as a pair of relations called the Fourier transforms:

$$e_1(t)=\frac{1}{2\pi}\int_{-\infty}^{\infty}\epsilon^{j\omega t}\boldsymbol{E}_1(\omega)d\omega \tag{11a}$$

$$\boldsymbol{E}_1(\omega)=\int_{-\infty}^{\infty}\epsilon^{-j\omega t}e_1(t)dt \tag{11b}$$

The function $\boldsymbol{E}_1(\omega)$ contains the continuous amplitude spectrum for $e_1(t)$, whereas equation 3 contained the *line* amplitude spectrum for a periodic function. A comprehensive table of Fourier transforms may be found in reference 12. Some authors prefer to split the $1/2\pi$ factor into $(1/\sqrt{2\pi})(1/\sqrt{2\pi})$ and associate one part with each transform.

As an example, the transform for the simple pulse function (Figure 8a) is found.

$$\boldsymbol{E}_1(\omega)=\int_{-t_1}^{t_1}\epsilon^{-j\omega t}dt$$

By direct integration of the exponential and substitution of the limits:

$$\boldsymbol{E}_1(\omega)=\frac{1}{j\omega}(\epsilon^{j\omega t_1}-\epsilon^{-j\omega t_1})$$

$$\boldsymbol{E}_1(\omega)=2\frac{\sin\omega t_1}{\omega} \tag{12}$$

This continuous amplitude spectrum is plotted in Figure 8b. Because of the symmetry of the pulse function, its transform is a real function of ω. If the area of the original pulse function is held constant at $2t_1=M$, and t_1 is allowed to approach zero, an impulse function will be obtained. Its transform is found from equation 12:

$$\boldsymbol{E}_1(\omega)=\lim_{t_1\to 0} M\frac{\sin\omega t_1}{\omega t_1}$$

$$=\lim_{t_1\to 0} M\frac{\omega\cos\omega t_1}{\omega}\text{ (by L'Hospital's rule)}$$

$$\boldsymbol{E}_1(\omega)=M$$

The transform for the unit impulse function (unit area) is simply unity. This is a very useful test function since its amplitude spectrum contains all frequencies, and the amplitude for each is the same, namely, unity.

The Fourier integral for the *response* of a system is obtained by substituting equation 3 in the Fourier series

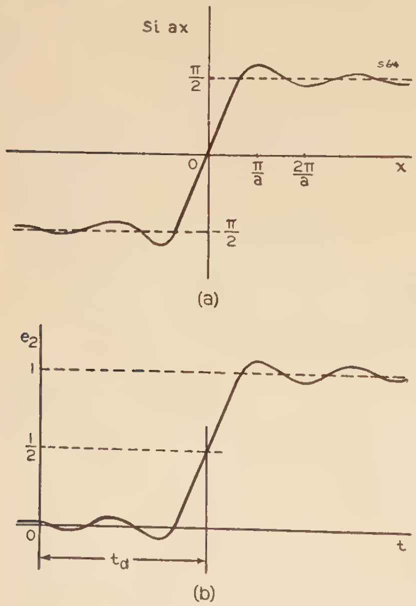


Figure 6 (left). Sine-integral function and response of a low-pass system to the unit step function

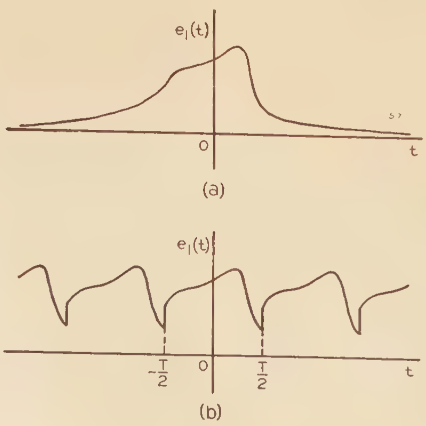


Figure 7. Periodic repetition of a portion of a function

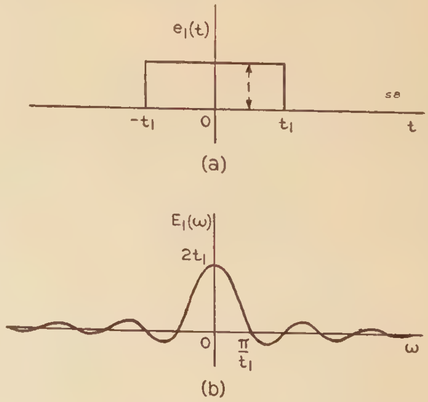


Figure 8. The simple pulse function and the corresponding continuous amplitude spectrum

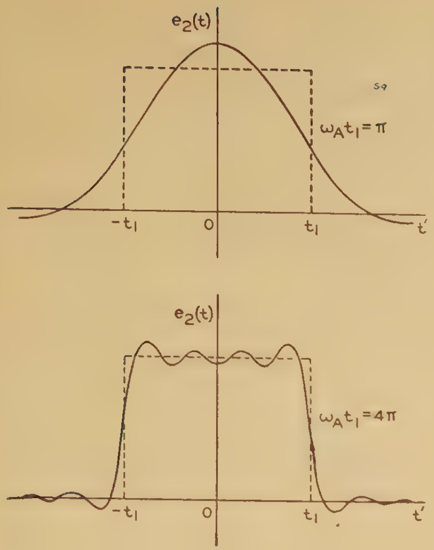


Figure 9 (left). Response of a low-pass system to a pulse function for two different cutoff frequencies

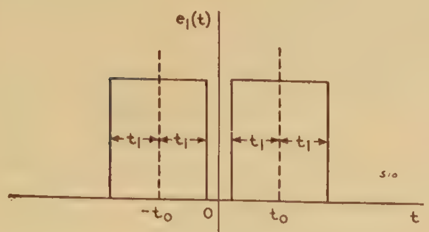


Figure 10 (above). A double pulse function

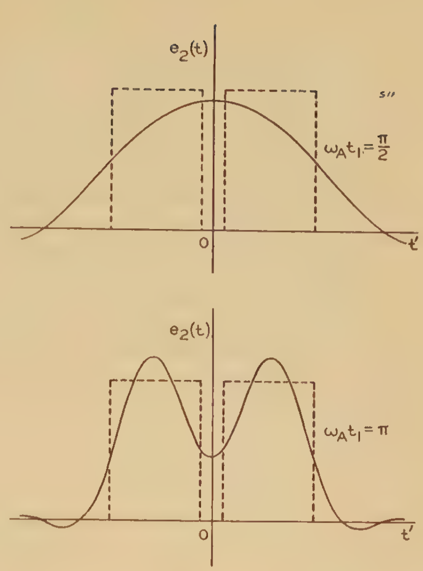


Figure 11 (right). Response of a low-pass system to a double pulse function for two different cutoff frequencies

for the response, equation 4, and again allowing the period to approach infinity.

$$e_2(t)=\frac{1}{2\pi}\int_{-\infty}^{\infty}\epsilon^{j\omega t}A(\omega)d\omega\int_{-\infty}^{\infty}\epsilon^{-j\omega t}e_1(t)dt \tag{13}$$

This may be written as:

$$e_2(t)=\frac{1}{2\pi}\int_{-\infty}^{\infty}\epsilon^{j\omega t}E_2(\omega)d\omega \tag{13a}$$

$$E_2(\omega)=A(\omega)E_1(\omega) \tag{13b}$$

In other words, if the transform for the perturbing force is multiplied by the complex transmission-frequency function of the system, the transform for the response will be obtained. This transform may then be inserted in equation 13a which gives the time expression for the response.

As an illustration of the method, let a pulse function (Figure 8a) be impressed on an idealized low-pass system (Figure 2). Since the largest amplitudes of the spectrum (Figure 8b) occur in the vicinity of the origin (zero frequency), it might be expected that the low-pass system would pass most of these components and give a reasonably faithful response. The fidelity will depend on the cutoff frequency, ω_A, however. From equation 12 and the transmission functions for the low-pass system, the transform of the response is found:

$$E_2(\omega)=2\frac{\sin\omega t_1}{\omega}\epsilon^{-j\omega t_d} \qquad -\omega_A<\omega<\omega_A$$

Inserting this in equation 13a, the response is given as:

$$e_2(t)=\frac{1}{\pi}\int_{-\omega_A}^{\omega_A}\epsilon^{j\omega(t-t_d)}\frac{\sin\omega t_1}{\omega}d\omega$$

Replacing the exponential by its trigonometric equivalent, the integrand becomes:

$$\frac{1}{\omega}[\cos\omega(t-t_d)\sin\omega t_1+j\sin\omega(t-t_d)\sin\omega t_1]$$

The first term is an even function of ω (since $1/\omega$ is odd); its integral is twice the integral from zero to ω_A. The second term is an odd function of ω; its integral is zero. The first term may be split into its side-band components, namely,

$$\frac{1}{2\omega}[\sin\omega(t-t_d+t_1)-\sin\omega(t-t_d-t_1)]$$

The expression for the response then becomes:

$$e_2(t)=\frac{1}{\pi}\int_0^{\omega_A}\frac{\sin\omega(t-t_d+t_1)}{\omega}d\omega-\frac{1}{\pi}\int_0^{\omega_A}\frac{\sin\omega(t-t_d-t_1)}{\omega}d\omega$$

$$e_2(t)=\frac{1}{\pi}[\mathrm{Si}\,\omega_A(t'+t_1)-\mathrm{Si}\,\omega_A(t'-t_1)] \tag{14}$$

where $t'=t-t_d$ for compactness. Thus the response, delayed by the time t_d, depends on the difference of two sine-integral functions, respectively leading and lagging by the time t_1. This result could have been obtained very easily by considering the pulse as composed of the difference of two displaced step functions, and using equation 10. Figure 9 shows the response (neglecting the delay time) with the original pulse in dotted lines, for two values of ω_A. The increase in fidelity for increase in the cutoff frequency (for a given value of t_1) is apparent.

As another simple example consider the response of the idealized low-pass system to a rapid succession of two-pulse functions. The perturbing force is shown in Figure 10. The response is found from the previous example by merely displacing the response to a single pulse, first forward, then backward, by t_0, and superposing the results. Thus the response to the double-pulse function is given analytically as:

$$e_2(t)=\frac{1}{\pi}[\mathrm{Si}\,\omega_A(t'+t_1-t_0)-\mathrm{Si}\,\omega_A(t'-t_1-t_0)]+\frac{1}{\pi}[\mathrm{Si}\,\omega_A(t'+t_1+t_0)-\mathrm{Si}\,\omega_A(t'-t_1+t_0)] \tag{15}$$

The response is plotted for four different values of ω_A in Figures 11 and 12. The increase in resolving power

with increase in ω_A is apparent (the original signal is shown in dotted lines).

Problems involving transients due to sudden changes in the amplitude of a carrier wave are handled most easily by the following method.[10] Suppose that a carrier wave modulated by some arbitrary transient-type function, say $f(t)$, is impressed on a linear system.

$$e_1(t)=f(t)\cos(\omega_c t+\alpha)=\text{Real part of } f(t)\epsilon^{j\alpha}\epsilon^{j\omega_c t}$$

where ω_c is the carrier frequency, and α is an arbitrary phase angle. For compactness let R be used for "Real part of." The response will be given, in general, by equation 13.

$$e_2(t)=R\epsilon^{j\alpha}\frac{1}{2\pi}\int_{-\infty}^{\infty}\epsilon^{j\omega t}A(\omega)d\omega\int_{-\infty}^{\infty}\epsilon^{-j(\omega-\omega_c)t}f(t)dt$$

The constant phase angle immediately appears outside the integral. Let $\omega'=\omega-\omega_c$ and substitute in the above relation.

$$e_2(t)=R\epsilon^{j(\omega_c t+\alpha)}\frac{1}{2\pi}\int_{-\infty}^{\infty}\epsilon^{j\omega' t}A(\omega'+\omega_c)d\omega'\int_{-\infty}^{\infty}\epsilon^{-j\omega' t}f(t)dt$$

This device removes the carrier wave from within the integral since ω_c and t are constants within the first integral. Now ω' is a variable of integration; it does not appear in the final value of the integral, and any symbol may be used instead of ω'; let us use ω again.

$$e_2(t)=R\epsilon^{j(\omega_c t+\alpha)}\frac{1}{2\pi}\int_{-\infty}^{\infty}\epsilon^{j\omega t}A(\omega+\omega_c)d\omega\int_{-\infty}^{\infty}\epsilon^{-j\omega t}f(t)dt$$

The second integral is the Fourier transform, $F(\omega)$, corresponding to $f(t)$. The double integral is the Fourier integral for the response due to a perturbing force, $f(t)$, impressed on a system of which the transmission-frequency characteristic is that of the original system, but shifted to the left by the amount ω_c (Figure 13). This response is a function of time, but is complex in general. Let

$$M(t)\epsilon^{j\psi(t)}=\frac{1}{2\pi}\int_{-\infty}^{\infty}\epsilon^{j\omega t}A(\omega+\omega_c)F(\omega)d\omega \qquad (16)$$

Then

$$e_2(t)=RM(t)\epsilon^{j[\omega_c t+\alpha+\psi(t)]}$$

Therefore

$$e_2(t)=M(t)\cos[\omega_c t+\alpha+\psi(t)] \qquad (17)$$

Thus the response consists of the carrier wave amplitude-modulated by the envelope $M(t)$, and containing phase modulation due to $\psi(t)$. Frequently the response is demodulated so that the envelope only is of importance.

These examples serve to illustrate the method, and to suggest possibilities inherent in the use of the Fourier integral and its transforms. Additional material will be found in references 10 and 16. Applications in television systems are shown in reference 13 (appendix D). References 14 and 15 describe applications to selective-side-band systems. Use of the Fourier transforms to obtain certain general solutions of the wave equation is described in reference 16.

TRANSMISSION CHARACTERISTICS—FOURIER-SERIES REPRESENTATION

If the transmission-frequency functions $A(\omega)$ and $\theta(\omega)$ are given as plotted curves, obtained either by computation or by direct measurement,[18] it is necessary to fit empirical analytical expressions to these curves before attempting to evaluate the Fourier integral for the response. Otherwise, the successive graphical integrations involved will require a prohibitive amount of labor. Various empirical curves have been used for $A(\omega)$, the amplitude function; combinations of straight lines,[10, 14] exponential and trigonometric functions,[13] and combinations of straight lines with trigonometric functions[7] are examples. Usually, linear phase characteristics have been assumed, although this assumption may be considerably in error.[18]

A powerful general method[20] of obtaining analytical expressions for both the phase and the amplitude functions is to describe their departures from linearity in terms of sine and cosine functions of ω. Consider an amplitude function, $A(\omega)$, such as that shown in Figure 1. Beyond some particular value of ω, say ω_A, the amplitude may be assumed to be zero. Between $-\omega_A$ and ω_A, the function may be described by means of a Fourier series with respect to ω. The period is $2\omega_A$; the radian frequency of the fundamental is $2\pi/2\omega_A=t_A$. Since $A(\omega)$ is an even function of ω, no sine terms will be present. Then

$$A(\omega)=A_0+a_1\cos\omega t_A+a_2\cos 2\omega t_A+\ldots \qquad -\omega_A<\omega<\omega_A$$

$$A(\omega)=A_0+\frac{a_1}{2}(\epsilon^{-j\omega t_A}+\epsilon^{j\omega t_A})+\frac{a_2}{2}(\epsilon^{-j2\omega t_A}+\epsilon^{j2\omega t_A})+\ldots \qquad (18)$$

In these equations A_0 is the average value of $A(\omega)$. The coefficients a_n may be found by the method of selected

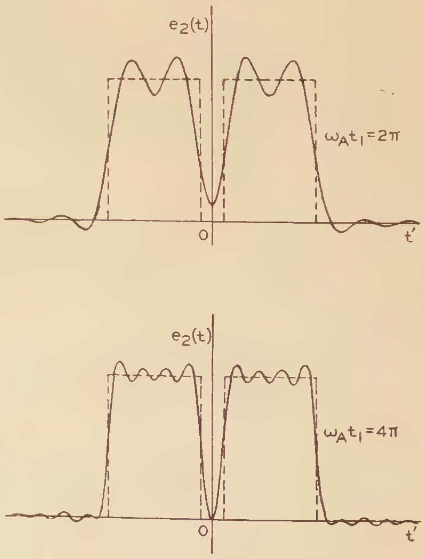


Figure 12. Response of a low-pass system to a double pulse function, showing the improvement in definition as the cutoff frequency is increased

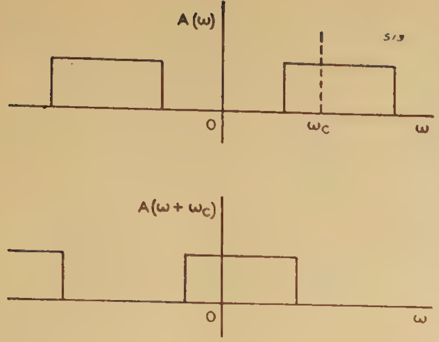


Figure 13. The amplitude function for a band-pass system before and after shifting

ordinates;[17] possibly only one cosine term need be taken and a judicious guess might give its amplitude and frequency. The Fourier integral for the response of a system, equation 13, may be written as

$$e_2(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} \epsilon^{j[\omega t - \theta(\omega)]} A(\omega) \boldsymbol{E}_1(\omega) d\omega$$

where $\boldsymbol{E}_1(\omega)$ is the transform of the perturbing force. Substitute equation 18 for $A(\omega)$ and let

$$e_3(t) = \frac{1}{2\pi}\int_{-\omega_A}^{\omega_A} \epsilon^{j[\omega t - \theta(\omega)]} \boldsymbol{E}_1(\omega) d\omega \tag{19}$$

Then

$$e_2(t) = A_0 e_3(t) + \frac{a_1}{2}[e_3(t-t_A) + e_3(t+t_A)] + \frac{a_2}{2}[e_3(t-2t_A) + e_3(t+2t_A)] + \ldots \tag{20}$$

Thus the response consists of a function, $A_0 e_3(t)$, such as would be transmitted by a low-pass system with a constant amplitude characteristic and sharp cutoff points, accompanied by a series of leading and lagging miniature replicas (echoes) of this function.

The phase function, $\theta(\omega)$, is an odd function of ω; it may be considered as a straight line, ωt_d, plus an odd function of ω which represents the deviation of $\theta(\omega)$ from the straight line (Figure 1). The deviation may be expressed as a Fourier series with respect to ω, containing sine terms only; the period need not be the same as that used for the amplitude function; let it be $2\omega_B$, say. The radian frequency of the fundamental component is then $2\pi/2\omega_B = t_B$, and

$$\theta(\omega) = \omega t_d + b_1 \sin \omega t_B + b_2 \sin 2\omega t_B + \ldots$$

$$\epsilon^{-j\theta(\omega)} = \epsilon^{-j\omega t_d}\epsilon^{-jb_1 \sin \omega t_B}\epsilon^{-jb_2 \sin^2 \omega t_B} \ldots \tag{21}$$

Two relations from the theory of Bessel functions are needed here. They are:

$$\epsilon^{\pm jb \sin x} = \sum_{-\infty}^{\infty} \epsilon^{\pm jnx} J_n(b)$$

(where n assumes all integer values as well as zero) and

$$J_{-n}(b) = (-1)^n J_n(b)$$

in which $J_n(b)$ is the Bessel function of the first kind, of order n. Accordingly

$$\epsilon^{-jb_1 \sin \omega t_B} = J_0(b_1) + J_1(b_1)[\epsilon^{-j\omega t_B} - \epsilon^{j\omega t_B}] + \ldots$$

When b is small compared with unity,

$$J_n(b) \approx \frac{b^n}{2^n n!}, \quad J_0(b) \approx 1, \quad Z_1(b) \approx \frac{b}{2}$$

and the higher-order terms are negligible.[9] Often a single sine term is sufficient to represent the deviation of $\theta(\omega)$ from a straight line; assume that it is $b_1 \sin \omega t_B$. Then

$$\epsilon^{-j\theta(\omega)} = J_0(b_1)\epsilon^{-j\omega t_d} + J_1(b_1)[\epsilon^{-j\omega(t_d+t_B)} - \epsilon^{-j\omega(t_d-t_B)}] + \ldots \tag{21a}$$

Substitute in equation 19:

$$e_3(t) = J_0(b_1)e_4(t') + J_1(b_1)[e_4(t'-t_B) - e_4(t'+t_B)] + \ldots \tag{22}$$

where

$$e_4(t') = \frac{1}{2\pi}\int_{-\omega_A}^{\omega_A} \epsilon^{j\omega t'} \boldsymbol{E}_1(\omega) d\omega \tag{23}$$

and

$$t' = t - t_d$$

Thus $e_3(t)$, the response of a system with an ideal amplitude characteristic, but nonlinear phase characteristic, may be expressed as a function $J_0(b_1)e_4(t')$, accompanied by lagging and leading miniature replicas (echoes) of this function; $e_4(t')$ is the response of an idealized low-pass system (Figure 2). Deviations of either the amplitude or the phase function from the ideal types produce echoes in the response. The final expression for the response is found by substitution of equation 22 in equation 20.

$$e_2(t) = A_0 J_0(b_1)e_4(t') + A_0 J_1(b_1)[e_4(t'-t_B) - e_4(t'+t_B)] + \frac{a_1}{2}J_0(b_1)[e_4(t'-t_A) + e_4(t'+t_A)] + \frac{a_1}{2}J_1(b_1)[e_4(t'-t_A-t_B) - e_4(t'-t_A+t_B) + e_4(t'+t_A-t_B) - e_4(t'+t_A+t_B)] + \ldots \tag{24}$$

Thus the expression for the response involves the evaluation of a single integral only, namely, expression 23, the response to the given signal of an ideal low-pass system having the average amplitude and phase characteristics of the given system. The departure of the characteristics from the ideal ones produces leading and lagging replicas of this function, or echoes. More material will be found in reference 20; a general solution due to L. A. MacColl is given in the discussion of that paper by C. R. Burrows.

The transient response of linear systems comprised of known configurations of concentrated, or distributed, elements of resistance, inductance, and capacitance may be determined effectively by means of the Laplace transforms, or (for those who prefer) the operational calculus. Other articles in this series describe these methods (references 1, 2, and 3). Interesting examples, including linear vacuum-tube amplifiers may be found in reference 21.

When a system becomes so complex that it is difficult to analyze it in terms of the individual elements, it may

be advisable to adopt a somewhat different point of view, namely, that of placing the entire system in a box (figuratively speaking) and of studying it from the standpoint of its over-all a-c steady-state transmission-frequency characteristics. The Fourier integral, closely allied to the Fourier series, furnishes a powerful method of dealing with such systems.

The purpose of this article is to present the Fourier integral and to illustrate its power in dealing with certain problems in the general (or transient) analysis of linear systems. From one viewpoint, however, the Fourier integral may be considered as the fundamental tool in dealing with the general analysis of linear systems, that the Laplace transforms are merely a branch of this general method, and that the operational calculus is a compact, shorthand method of using these ideas. In order to show this general correlation, a derivation of the Laplace transforms from the Fourier integral is presented in the appendix.

Appendix

In a great many problems the response involves functions that may be considered as zero for all negative values of the variable. The Fourier transform for such a function is, from equation 11b

$$\boldsymbol{F}(\omega)=\int_0^{\infty}\epsilon^{-j\omega t}f(t)dt \qquad (25)$$

The inverse transform (11a) is not altered in form

$$f(t)=\frac{1}{2\pi}\int_{-\infty}^{\infty}\epsilon^{j\omega t}\boldsymbol{F}(\omega)d\omega \qquad (26)$$

If $\int_0^{\infty}|f(t)|dt$ does not exist, there will be difficulty in finding the Fourier transform $\boldsymbol{F}(\omega)$. In such cases the function may be multiplied by an attenuating function and the transform obtained as in the following example.

$$f(t)=\sin mt \qquad 0<t$$
$$f(t)=0 \qquad t<0$$

When substituted in equation 25 an integral is obtained which cannot be evaluated (since the sine and cosine functions are not definite at infinity). Next consider

$$f(t)=\lim_{c\to 0}\epsilon^{-ct}f(t)=\lim_{c\to 0}\epsilon^{-ct}\sin mt \qquad 0<t$$

where c is a positive real constant.
Then

$$\boldsymbol{F}(\omega)=\lim_{c\to 0}\int_0^{\infty}\epsilon^{-j\omega t}\epsilon^{-ct}\sin mt\,dt$$

$$=\lim_{c\to 0}\frac{m}{(j\omega+c)^2+m^2}=\frac{m}{(j\omega)^2+m^2}$$

The transform is thus obtained by a passage to a limit. In the tables of Campbell and Foster,[12] the method of obtaining transforms by passage to a limit is clearly shown for each transform.

In order to avoid the method of procedure to a limit, write the Fourier integral for $\epsilon^{-ct}f(t)$:

$$f(t)\epsilon^{-ct}=\frac{1}{2\pi}\int_{-\infty}^{\infty}\epsilon^{j\omega t}d\omega\int_6^{\infty}\epsilon^{-(c+j\omega)t}f(t)dt \qquad 0<t$$

Substitute $p=c+j\omega$

$$f(t)\epsilon^{-ct}=\frac{1}{2\pi}\int_{c-j\infty}^{c+j\infty}\epsilon^{pt}\epsilon^{-ct}\frac{dp}{j}\int_0^{\infty}\epsilon^{-pt}f(t)dt \qquad 0<t$$

In this equation, ϵ^{-ct} may be removed from under the integral sign and cancelled from both sides:

$$f(t)=\frac{1}{2\pi j}\int_{c-j\infty}^{c+j\infty}\epsilon^{pt}dp\int\epsilon^{-pt}f(t)dt \qquad 0<t \qquad (27)$$

Finally:

$$f(t)=\frac{1}{2\pi j}\int_{c-j\infty}^{c+j\infty}\epsilon^{pt}F(p)dp \qquad 0<t \qquad (27a)$$

where

$$F(p)=\int_0^{\infty}\epsilon^{-pt}f(t)dt \qquad (27b)$$

These are the Laplace transforms; p has a positive real part sufficiently large to make the integral 27b convergent.

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INSTITUTE ACTIVITIES

1942 Summer Convention Planned for Work

As already announced, the annual AIEE summer convention will be held in Chicago, Ill., June 22–26, 1942, with convention headquarters in the Drake Hotel. The recommendation of the board of directors that because of the war the summer convention be made a working convention is reflected in the program arranged. Thus, in addition to the annual meeting, conference of officers, delegates, and members, and the general session, there are a total of 21 sessions and conferences scheduled during the mornings and afternoons. Attractive entertainment features have been arranged in the evenings, beginning with the president's reception and dance on Monday, which is sponsored by the Chicago Section. The women's entertainment committee is making arrangements for the entertainment of the visiting women during the convention.

TECHNICAL SESSIONS

Several of the technical sessions and conferences are closely related to the war effort, such as the symposium on mercury-arc rectifier applications and the conference on education. Several sessions will feature the subjects of lightning and cables. The phenomena of the lightning stroke and its effect upon materials and apparatus will be fully discussed. Other papers will describe a modern cathode-ray oscillograph and impulse generators for the testing of lightning arresters. The subject of cables will be treated extensively from the fundamental aspects of the life of impregnated paper, short-time heating, and load ratings, through to a description of the most modern 120-kv compression and gas-filled pipe-type cable. Another session of outstanding importance will deal with the emergency overload operation of transformers and rotating machinery. The current ratings of electronic devices for intermittent service will be the subject of discussion in still another session.

ENTERTAINMENT

In addition to the evening features in the accompanying schedule of events the various subcommittees are actively at work on plans for trips, sports, and other entertainment, which will be announced in detail later.

Annual Meeting

The annual meeting of the American Institute of Electrical Engineers will be held at the Drake Hotel, Chicago, Ill., at 10:00 a.m. on Monday, June 22, 1942. This will constitute one session of the summer convention.

At this meeting, the annual report of the board of directors and the report of the committee of tellers on the ballots cast for the election of officers will be presented.

Such other business, if any, as properly may come before the annual meeting may be considered.

(*Signed*) H. H. HENLINE
National Secretary

Tentative Schedule of Events

Monday, June 22

9:00 a.m.	Registration
10:00 a.m.	Annual meeting
12:00 m.	Luncheon conference of Branch counselors
2:00 p.m.	Conference on local engineering councils
2:00 p.m.	Power generation
2:00 p.m.	Conference on lighting for protection
Evening	President's reception, dance

Tuesday, June 23

9:30 a.m.	Switching equipment
9:30 a.m.	Communication
9:30 a.m.	Instruments and measurements
2:00 p.m.	Conference of officers, delegates, and members
Evening	Beaches and boulevards of Central and South America

Wednesday, June 24

9:30 a.m.	Lightning and miscellaneous
9:30 a.m.	Overload operation of transformers and rotating machinery
9:30 a.m.	Conference on electronic control of resistance welding
12:30 p.m.	Board of directors' luncheon meeting
2:00 p.m.	Protective relays
2:00 p.m.	Power transmission
2:00 p.m.	Electronics
Evening	Edgewater Beach Hotel; WENR broadcast station; or Adler Planetarium

Thursday, June 25

10:00 a.m.	General session
2:00 p.m.	Transmission and distribution
2:00 p.m.	Transportation
2:00 p.m.	Conference on education
Evening	Convention banquet

Friday, June 26

9:30 a.m.	Mercury-arc rectifier applications
9:30 a.m.	Basic sciences
9:30 a.m.	Selected subjects
12:30 p.m.	Luncheon; presentation of sports' prizes
2:00 p.m.	Industrial power applications
2:00 p.m.	Cables
2:00 p.m.	Transportation

STANDARDS . . .

Definitions of Electrical Terms

A new American Standard known as "Definitions of Electrical Terms, C42," sponsored by the AIEE, is now ready for general distribution. The publication of this volume of electrical definitions as an American Standard marks an epoch in the literature of the electrical art in America, as the first time the definitions of the important terms common to all branches of the art, as well as those specifically related to each of the various branches, have been assembled and printed under one cover.

This glossary is the result of more than 12 years' work of a sectional committee of 46 members, having 18 subcommittees drawn from available specialists. More than 300 individuals have given material assistance and many others have assisted in specific instances. The 34 organizations represented on this sectional committee include the national engineering, scientific, and professional societies, trade associations, government departments, and miscellaneous groups.

ORIGIN OF THE PROJECT

The International Electrotechnical Commission in 1910 appointed a committee on nomenclature, for the purpose of drafting an international list of terms and definitions. As standardization, both national and international, was at that time very much in its infancy, the work progressed very slowly for some years.

The first work of the IEC Advisory Committee on Nomenclature, under the chairmanship of the late Doctor C. O. Mailloux, consisted of making an exhaustive study of all the recognized systems for classification and numbering of terms in a technical glossary. The system employed in the new American Standard is that adopted at the Bellagio meeting of 1927 and employed in the international vocabulary of some 1,860 terms issued in 1938. Its adoption was based on the belief that it permits the great-

Future AIEE Meetings

Summer Convention
Chicago, Ill., June 22–26, 1942

Pacific Coast Convention
Vancouver, B. C., September 9–11, 1942

Middle Eastern District Meeting
Pittsburgh, Pa., October 14–16, 1942

Winter Convention
New York, N. Y., January 25–29, 1943

est possible latitude for interpolation of terms necessitated by future developments without requiring change in established group and term arrangements and numbering.

For some time before the 1927 meeting of the IEC the United States National Committee of the IEC had been working toward the organization of a committee for the formulation of an American vocabulary, recognizing that the international list inevitably would contain but a fraction of the terms required for a serviceable American vocabulary.

The American Standards Association approved the initiation of the work in 1928 on the recommendation of the AIEE standards committee, the scope being outlined as: "Definitions of technical terms used in electrical engineering, including correlation of definitions and terms in existing standards." Under this authorization, the Sectional Committee on Definitions of Electrical Terms, *C*42, was organized during the same year, under the sponsorship of the AIEE and chairmanship of Doctor A. E. Kennelly. In 1932 the first report was printed, and 3,000 copies were distributed for comment and criticism. In 1937 the second general revision was compiled and distributed. Early in 1940, C. H. Sanderson was appointed chairman to fill the vacancy created by the death of Doctor Kennelly in 1939, and the final preparation of the work for approval and publication as an American Standard was brought to a close in the spring of 1941.

OBJECTIVES

The primary aim in the formulation of the definitions has been to express for each term the meaning which is generally associated with it in electrical engineering in America. The definitions have been generalized wherever practicable to avoid precluding the various specific interpretations that may be attached to a term in particular applications. It has been recognized that brief, simplified phrasing usually presents the clearer word picture. Amplifying notes accompany certain definitions when the added information is particularly helpful, but those notes are not a legitimate part of the standard phrasing. Words used in the definitions have been employed in the accepted meaning as given in the recognized dictionaries, unless they have been defined specifically in this glossary. Specialized definitions for common words have been discouraged.

Prior to the inception of this work the definitions to be found in the literature of the electrical art were comparatively few and very widely scattered, and their formulation as to substance and expression was generally the work of individuals or small groups. Many of these had gained some measure of approval in that branch of the art responsible for their formulation, but were practically unknown elsewhere. Some groups of general terms had long been the subject of much controversy. The engineer or scientist or student who wished to have ready access to the definitions actually existing in printed form was faced with the necessity of assembling a sizable library. Moreover, in some cases he then had to choose between two or more definitions of the same term.

This new American Standard has unified and perfected the existing groups of definitions, rounded out these groups, and added many new groups. It covers more than three times as many terms as have been assembled for this field in any other language, and has been thoroughly indexed. It should prove of great value to the general public as well as to scientists and engineers, as an extension of the function of the recognized dictionaries into specialized fields not hitherto covered.

Copies of "Definitions of Electrical Terms," 300 pages, 8 by 11 inches, fabrikoid binding, may be obtained at $1 per copy net in the United States, $1.25 elsewhere, from AIEE headquarters, 33 West 39th Street, New York, N. Y.; checks or money orders should be made payable to AIEE.

SECTION • • • • •

Factory Distribution Systems Subject of Michigan Meeting

A joint dinner meeting of the Industrial Electrical Engineering Society, Detroit, Mich., and the industrial power applications group of the AIEE Michigan Section was held on March 25, 1942, at the Detroit plant of the United States Rubber Company, with 200 electrical engineers present.

The general subject of the meeting was "Electrical Distribution Systems for Factories." Each of the following speakers presented description and discussion of the type of electrical distribution system adopted by his company for plants in the present war program: E. L. Bailey (M'25), Chrysler Corporation; Leonard Bogardus, Packard Motor Car Company; Howard Truesdale, Kelsey Hayes Wheel Company. James Bishop (F'42) of the Ford Motor Company presided at the meeting and Dale Douglas of the Chevrolet Motor Company led the discussion. Those who took part in the discussion were: George Bagley, Chrysler Corporation; George Owens, Briggs Manufacturing Company; W. T. Latham, Consumers Power Company (Battle Creek); Ben A. Clark, Plymouth Motor Company; Art Shimmin, Rotary Electric Steel Company. The meeting was also briefly addressed by J. J. Orr (A'30),

A skyline view of Chicago, Ill., site of the AIEE 1942 summer convention

At Detroit meeting, left to right are: back row, Messrs. Bagley, Truesdale, Chute, Messinger, Douglas, Latham, L. W. Clark, B. Clark, Horn, and T. Duffy, United States Rubber Company; front row, Messrs. Bailey, Bogardus, Owens, Bishop, John, Shimmin, Orr.

United States Rubber Company (New York), chairman of the AIEE national committee on industrial power applications.

General arrangements for the meeting were in the hands of Kurt John (M'41), United States Rubber Company; George Chute (M'33), General Electric Company; L. W. Clark (A'25), Detroit Edison Company; Claude Messinger, Revere Copper and Brass Company; Ben Clark; and Marvin Horn, ITE Circuit Breaker Company.

Electricity on Streamliners Discussed at Chicago

The use of electricity on streamline trains was the subject of a talk by M. J. Stephenson, electrical engineer of the Pullman Car and Manufacturing Company, Chicago, Ill., at a meeting of the power group of the AIEE Chicago Section on March 12, 1942.

On the older Pullman cars electricity was used only for lighting and annunciator systems, he said, whereas on modern streamliners it is being used for air conditioning, radios, public address systems, telephones, and brakes, with the result that electric loads have been greatly increased. To cope with this situation, the electric power equipment on some of the newer trains has been placed on one car with feeder circuits running to the other cars on the train. In comparison with the older, more general practice of using a shaft-driven generator for each Pullman car, it was pointed out that this arrangement may be disadvantageous in that it requires the service of the power-equipment car whenever the newer cars are used.

Meeting for Young Engineers Sponsored by the Chicago Section

An innovation in the form of a dinner meeting which brought students and young engineers into contact with engineers who are established in the profession was featured by the AIEE Chicago Section on March 5, 1942. The seating, arranged so that one or two experienced engineers were at each table, was designed to give young engineers an opportunity to meet men active in the field of electrical engineering and in AIEE activities. "Getting Started in Engineering," was the subject of a talk by Alex D. Bailey, chief operating engineer of the Commonwealth Edison Company, Chicago, Ill., planned to be of special interest to the young engineers present and "The Engineer and the Postwar World," a paper presented by Frank F. Fowle (A'02, M'12) head of the firm, Frank F. Fowle, Chicago, Ill., was of timely interest to all.

Black-Outs and Black-Out Lighting Considered at New York

At a meeting of the illumination group of the AIEE New York Section on March 12, 1942, information on black-outs was given by S. R. McCandless, associate professor of lighting at Yale University, New Haven, Conn., and chairman of the black-out council of the Connecticut State Defense Council. Stating that there are as yet no official regulations for black-out procedure other than those issued by local authorities, he pointed out that until definite rules are established, black-outs should be complete, which means that all lights should be out or obscured, that street lights should be extinguished, and traffic stopped.

In moonlight, which has an average light intensity of about .02 foot-candle, a bombardier who flies at heights of from 10,000 to 30,000 feet over a terrain of which he probably has some knowledge, needs no further light to find his objective, it was cited. Since rivers and roads are often guides and since brightness, contours, and contrasts seen from above aid in locating objectives, very low levels of light intensity are necessary during black-outs. In London, Professor McCandless said, a special protected and enclosed street light with a 40-watt lamp has been developed. These are spaced from 200 to 300 feet on centers and give only two or three times the intensity of starlight, which is approximately .0002 foot-candle.

Various types of lighting for black-outs were discussed by S. H. Hibben (A'34) director of applied lighting, Westinghouse Lamp Division, Westinghouse Electric and Manufacturing Company, Bloomfield, N. J., who suggested a small, shielded, red light sufficient to permit people to move about without accident for interior light during black-outs. A yellow light, he said, might be used, but blue should be avoided, as it is most easily discernible.

Fluorescent materials which are excited by daylight, by ordinary incandescent light, and to a greater degree by fluorescent light were mentioned. These glow for some time after the exciting light has been extinguished with sufficient intensity for people to move about, the period of glow, which may be for several hours with decreasing intensity, depending upon the material used. This material, which produces light of an intensity so low as not to be objectionable during black-outs, is not yet available, it was pointed out, but is being investigated for use in the home, in commercial and industrial establishments, and for guiding signs, either indoors or outdoors.

Exchange of Gold for Strategic Materials Advocated

"Gold Versus Strategic Minerals" was the subject of a talk by Doctor D. H. McLaughlin at a meeting of the AIEE San Francisco Section on February 27, 1942, in which it was suggested that the United States re-exchange its stockpile of 22 billion dollars in gold for such strategic minerals as tin, manganese, mercury, tungsten, antimony, and chrome.

A few years ago, he pointed out, the United States sold quantities of its resources to countries with which it is now at war in exchange for 14 billion dollars. This raised gold accumulation to 22 billion dollars, which today has only token value to the United States, which does not possess the raw material that would now be most useful. The idea of accumulating stockpiles of strategic raw materials, not available locally, began several years ago, and although Congress voted funds for this purpose, the total was not adequate to purchase materials to meet present needs.

There was also some fear that the practice might stifle local industries or give the Government control over prices.

Some facts on the present sources and supplies of strategic minerals were given as follows:

Tin—Bolivia, with a yearly capacity of 50,000 tons, is the only source available to the United States today. Increased smelting capacity is now in progress. In 1941 the United States imported 143,000 tons.

Manganese—South Africa, India, Russia, and South America are the United States' best sources of supply. Deposits are widely distributed but few are of high grade. The United States uses over a million tons per year, having produced in 1940 only 40,000 tons and in 1941, four or five times that amount. Present reserves in the United States are estimated to be two million tons.

Tungsten—California and Nevada have been producing it for a number of years and increased supplies are available, although normally they cannot compete without tariff protection.

In comparison, it was pointed out that Japan possesses nearly ninety per cent of the world's supply of tin and now has access to manganese, chromite, and tungsten from the Philippine Islands, and bauxite from the Dutch East Indies.

ABSTRACTS • • •

TECHNICAL PAPERS previewed in this section will be presented at the AIEE summer convention, Chicago, Ill., June 22–26, 1942, and are expected to be ready for distribution in advance pamphlet form within the current month. Copies may be obtained by mail from the AIEE order department, 33 West 39th Street, New York, N. Y., at prices indicated with the abstract; or at five cents less per copy if purchased at AIEE headquarters or at the convention registration desk.

Mail orders will be filled
AS PAMPHLETS BECOME AVAILABLE

Electrical Machinery

42-93—Application of Apparatus and Conductors Under Various Ambient Temperature Conditions; *R. E. Hellmund* (*A'05, F'13*), *P. H. McAuley* (*A'36*). *20 cents.* Various electrical standards are reviewed from the viewpoint of the selection and interpretation of ambient temperature values. Equivalent aging temperatures for insulation have been calculated from recorded ambient temperature data for several typical outdoor and indoor locations. From these the suitability of ambient values now used for standardization purposes is discussed. These values seem to be well chosen but some clarification in meaning and in methods of using them for rating purposes is desirable. For apparatus rated on a 40 degrees centigrade ambient basis, appreciable margins in permissible temperature rise exist under many conditions and for many places of application. Permissible increases in loading for certain motors without exceeding conservative hot-spot temperatures are suggested.

42-98—Factors Affecting the Mechanical Deterioration of Cellulose Insulation; *F. M. Clark* (*A'24*). *25 cents.* The rate of mechanical deterioration of cellulose insulation is dependent on the conditions of its use. Those factors of major importance are the temperature applied and the presence of oxygen and moisture. Moisture even in small amounts greatly affects the mechanical stability of the cellulose insulation. In general, the mechanical life of the insulation is reduced by half for each doubling in water content. Deterioration promoted by oxidation is most effective at temperatures below 120 degrees centigrade and is accelerated by the presence of moisture. The rate of deterioration for substantially dry insulation at temperatures above 120 degrees centigrade is dependent upon its previous history. Intermittent exposure to high temperature effects are additive. The "8 degrees centigrade rule" indicative that the rate of mechanical deterioration is doubled for each 8 degrees centigrade increase from a base temperature of 120 degrees centigrade or higher applies most closely for practical use when the insulation under study has lost more than 50 per cent of its tensile strength.

42-89—Steady-State Theory of the Amplidyne Generator; *T. D. Graybeal* (*A'38*). *20 cents.* The fundamental steady-state theory of the amplidyne generator is presented, with methods for calculating the characteristics of the generator from the machine constants. Experimental data obtained on a test machine are compared with calculated results to show the accuracy of the methods and to substantiate the theory. The effects of such factors as brush losses, commutation, and over- and under-compensation on the operation of the generator are explained. Over- and under-compensated machines are treated from the standpoints of steady-state operation and electrical stability. Methods are given for the determination of the machine constants from open-circuit and short-circuit tests performed on the machine. This method offers the advantage that the machine constants so determined apply for actual conditions of operation and need not be modified to include the effects of such factors as brush and commutation losses, eddy currents, and hysteresis.

42-100—Field Harmonics in Induction Motors; *M. M. Liwschitz* (*M'39*). *30 cents.* This is the first of a series of three papers on harmonics in induction motors. It presents formulas for the order of the harmonics of stator and rotor, for the amplitudes and speed of the harmonics with regard to stator and rotor, taking into account integral as well as fractional numbers of slots per pole per phase. Formulas for the number of poles of the force waves produced by the stator and rotor harmonics separately as well as in co-operation are derived and the frequencies of these force waves are determined. The consideration of the force waves is not limited to the most dangerous slot harmonics; experience shows that the fifth and seventh harmonics may be disagreeable also. Attention is paid to the force waves with two poles ($k=1$), to which the stator is in general less stiff than to the short waves, but the stationary waves ($k=0$) also are taken into account since these waves under certain circumstances produce heavy noise. The influence of saturation is discussed and the frequencies of the force waves caused by the saturation are determined.

42-101—Emergency Overloads for Oil-Insulated Transformers; *F. J. Vogel* (*A'21, M'41*), *T. K. Sloat.* *15 cents.* The effects of time and temperature upon the strength of insulation form the starting point for estimates of overloads of transformers and their durations; tests relating to this problem have been made and reported heretofore in several AIEE papers. This paper reports new tests made largely upon insulating materials immersed in oxygen-free oil protected from exposure to oxygen by means of nitrogen atmospheres. It differs from previous studies on the subject in that definite evaluations of the effects of acidity on the insulation strength are given. Curves showing the relations between time and temperature and their effects upon insulating materials are reported. With these tests, a method of translating given deteriorations of insulation into overloads of given durations is developed and tables of permissible-emergency short-time overloads higher than those included in the American Standards Association "Guide for Operation of Transformers" are presented for discussion.

Electronics

42-87—Current Ratings of Electronic Devices for Intermittent Service; *R. E. Hellmund* (*A'05, F'13*). *15 cents.* Since electronic devices are used extensively in switching, relaying, welding, and similar services requiring intermittent loads, the assignment of ratings especially suited for these loads is discussed. Distinction is made between ratings suitable for single-anode tubes and circuit combinations consisting of several single-anode tubes or of multi-anode tubes and other apparatus. Various factors likely to influence the current ratings of tubes or their combinations are discussed. Conditions in vapor-filled tubes with oxide-coated filaments are covered in some detail but brief reference is also made to conditions encountered in pool-type and cold-cathode tubes. Methods of rating which seem to be generally applicable to many tubes and tube arrangements are suggested. It is also pointed out that after further study, certain questions of standardization should be settled in order to bring about a reasonably uniform practice. It is finally suggested that various tubes and applications not fully covered in the paper be further investigated for the purpose of determining whether the methods suggested, or modifications thereof, can be applied to most conditions of practical importance.

42-94—Analytical Treatment for Establishing Load-Cycle Ratings of Ignitrons; *D. E. Marshall* (*A'27, M'33*), *E. G. F.*

Arnott. *15 cents.* This paper outlines basic analytical methods to serve as an aid in establishing load-cycle ratings of ignitrons. The method outlined in the first part is applicable to various types of apparatus. In the latter part, specific conditions as encountered in ignitrons are taken into account. While some tests on specific tubes will be required to obtain final results, it is believed that the derivations given here will be of material assistance in establishing a rationalized system of ratings with a minimum of test work.

42-95—Regulated Rectifiers in Telephone Offices; *D. E. Trucksess* (*M '40*). *20 cents.* The thyratron tube lends itself to making a self-regulated rectifier. Two types of circuits are described to control by electronic means the output current of thyratron rectifiers by the voltage applied to the grids of the tubes to regulate the output voltage. An all-vacuum-tube regulated rectifier and a shunt-type circuit using a negative resistance are used in small sizes of rectifiers. For large size rectifiers a two-element rectifier tube using plate voltage control is described. A regulated tube rectifier is described which can be changed to an electronic invertor to supply a-c energy during a power failure from the battery it had been charging.

42-105—Ignitor Excitation Circuits and Misfire Indication Circuits; *A. H. Mittag* (*A '14, M '40*), *A. Schmidt, Jr.* (*A '35*). *15 cents.* Several circuits are available for excitation of ignitron rectifiers. Static magnetic impulse circuits are preferred in many cases. Three such circuits having different modes of operation are discussed in some detail. Ignitor requirements are given and tests are described for measuring excitation circuit capacity. While ignitor failures are rare, they should be detected promptly to utilize all apparatus to the best advantage. Two conditions may arise: (1) when two anodes operate in parallel from a single transformer winding, and (2) when a single anode is connected to each transformer winding. Means for detecting anode misfiring are described for both conditions.

42-106—Sealed Tube Ignitron Rectifiers; *M. M. Morack, H. C. Steiner* (*A '32*). *20 cents.* During the past few years, the desirable structural features and operating characteristics of mercury-arc rectifiers, as compared with other forms of converting equipment, have led to the installation of sealed ignitron-tube rectifier equipment to supply d-c power for industrial, mining, electrochemical, and general-purpose loads. These rectifiers range in capacity from 75 to 400 kw per unit with d-c potential outputs of 250 to 600 volts. Voltage control provides for either constant or variable potential outputs and for parallel operation with existing or duplicate power sources. The tubes are of the permanently evacuated, steel-jacketed, half-wave mercury pool type, in which the cathode spot excitation is established each positive half-cycle by means of ignitors. Separate excitation in which the ignition is independent of the load has been found preferable to anode-excitation for lighting and regenerative loads. The experience gained shows that by proper co-ordination of circuit and tube characteristics, service interruptions caused by arcbacks are negligible; that rectifier efficiency is high, ranging from 90 to 94 per cent depending upon voltage and rms loading; and that the tubes will give long and trouble-free service.

Industrial Power Applications

42-99—A 600-Volt Enclosed Limiter for Network Use; *P. O. Langguth* (*A '28, M '41*), *H. L. Rawlins* (*A '30, M '41*), *J. M. Wallace* (*A '41*). *15 cents.* The extension of the conventional network system to industrial plants has established requirements for a higher voltage limiter. The network system has been adopted as a standard by many utilities for 120–208-volt distribution, whereas industrial plant distribution is usually at higher voltages, ranging up to 600 volts, because of the predominance of power load. The requirements of a limiter for this service are more severe because of the proximity of operating personnel and increased interrupting duty associated with higher voltages and shorter cable runs. The paper discusses this new application of limiters and describes a totally enclosed limiter, developed for this service. This limiter embodies new principles of operation, and will interrupt fault curents in excess of 50,000 amperes at 600-volts without perceptible noise or visible demonstration.

Power Transmission and Distribution

42-88—Analysis of Short Circuits for Distribution Systems; *C. F. Dalziel* (*A '33, M '39*). *20 cents.* Many distribution systems are supplied from transformers connected delta on the low-voltage side with the midtap of one secondary, or with one corner of the delta, connected to ground. As a result, short circuits on these systems often involve failure to ground, and an accurate analysis for these faults is of value. An original analysis of power-leg-to-ground and light-leg-to-ground short circuits is presented together with formulas for line-to-line and three-phase faults. A study of short circuits on the secondary circuits of single-phase transformers supplied from three-phase systems is also included, thereby giving a comprehensive treatment of distribution short circuits. The paper also includes a discussion of the effects of resistance in limiting short-circuit currents and the voltage rise of the secondary neutral above ground potential caused by transformer failure and resistance to ground.

42-91—Practical Design of Counterpoise for Transmission-Line Lightning Protection; *E. Hansson* (*A '19, M '35*), *S. K. Waldorf* (*A '27, M '36*). *15 cents.* Buried counterpoise as a part of transmission-line lightning protection is generally accepted and simple formulas for correlating tower footing resistances with insulating levels are available. Analysis of counterpoise installations on several hundred miles of line reveal some practical limitations. It is not always economical to strive for the values of footing resistance indicated as desirable by these formulas, because each insulating level seems to have an optimum value of footing resistance below which little or no benefit results. While the total amount of conductor required to bring the ground resistances of a large number of structures down to a desired level can be reasonably well estimated, it is not possible to do this for individual structures. A practical procedure is the installation of an arbitrary length of conductor at each location and estimating the additional amount required from measurement of the ground resistance of this trial installation.

42-92—The Dielectric Strength and Life of Impregnated-Paper Insulation—III; *J. B. Whitehead* (*A '00, F '12*). *15 cents.* Of particular interest in this series of studies of the breakdown strength of impregnated paper is the controlled laboratory result that there is a marked decrease of dielectric strength with increasing paper density. This result was unexpected to many cable engineers and contrary to the practice of a number of manufacturers. The present paper reports further studies of this interesting and important difference between laboratory tests and experience. The paper also includes results showing that the dielectric strength is noticeably higher when impregnated with a thin oil than with a heavier oil. Other results on the influence of variations of other physical properties of cable insulation are reported. Of special interest is the development of a new method for detecting incipient failure in cable-type insulation and resulting new evidence of the initial mechanism of failure.

42-96—Modern Impulse Generators for Testing Lightning Arresters; *Theodore Brownlee* (*A '26*). *20 cents.* A wide variety of impulse generator circuit constants are required to produce the various impulse current waves used in lightning-arrester testing. It is not possible to determine mathematically the constants necessary to produce a specified wave, chiefly because of the nonlinear resistance of the lightning-arrester valve element. Simplified calculating methods are presented, enabling an approximate determination of the circuit constants without a process of trial and error. Several impulse generators are described having considerable flexibility and facility for quick adjustment.

42-102—Low-, Medium-, and High-Pressure Gas-Filled Cable; *G. B. Shanklin* (*A '16, M '29*). *25 cents.* After preliminary development work systematic laboratory tests, closely simulating service conditions, were started in 1934 leading towards final development and improve-

ment of gas-filled cable. The first full-size field installation of gas-filled cable was placed in service in 1938. The results of this work up to that time were summarized in a paper presented at the AIEE winter convention, January 1939 and published in *Transactions*, volume 58, 1939 (July section) pages 307–15. The present paper will deal with progress made since then, covering the whole range of voltage ratings from 10 kv to 138 kv, divided as follows: low-pressure gas-filled cable systems 10 kv to 40 kv, operating at gas pressures from 10 to 15 pounds per square inch; medium-pressure systems 40 kv to 69 kv, operating at gas pressures from 24 to 40 pounds per square inch; high-pressure systems 69 kv to 138 kv, operating at gas pressures from 150 to 200 pounds per square inch.

42-103—Induced Voltages on Transmission Lines; *C. F. Wagner (A '20, F '40), G. D. McCann (A '38). 30 cents.* The present knowledge of the mechanism of the lightning stroke permits an accurate determination of the magnitude and wave shape of voltages produced on transmission lines by indirect strokes. The velocity of initial downward leaders of lightning strokes is usually too low to produce significant voltages on transmission lines by induction. Only the return streamers are of importance. The voltages produced by the latter can be determined to sufficient accuracy by representing the return streamer as a vertically propagating conductor whose tip moves with uniform velocity, neutralizing, as it progresses, the uniformly distributed charges on the initial streamer. In spite of the high currents and the short duration of the return streamer, only the charge, and not the high rate of change of the current, is important. The voltages so produced are primarily a function of the height of the transmission-line conductor, the crest of the current in the stroke at ground and the velocity of the return streamer. By choosing the probability of occurrence of stroke currents and corresponding return streamer velocities, the probability of occurrence of induced voltages as a function of their magnitude can be determined. Although the voltages induced by lightning on transmission lines may be quite high, those of sufficient magnitude to produce flashover occur so infrequently as to be of little practical importance.

42-104—The Effect of Lightning on Thin Metal Surfaces; *K. B. McEachron (A '14, F '37), J. H. Hagenguth (A '28). 20 cents.* In the search for means for measuring the properties of natural lightning, much can be learned from the evidence left at points struck by lightning. The paper deals principally with such evidence in the form of holes burned in thin copper and iron sheets and the process of evaluating the characteristics of the lightning strokes responsible for the evidence from laboratory tests. Such evidence has shown values up to 240 coulombs which are due to continuous strokes of lightning. High-current discharges are shown to produce evidence of entirely different nature. Two cases of severe lightning damage are described, one, to a home, suggesting a 200,000-ampere current peak followed by continuous discharge of 240 coulombs. Results indicate that sheet metal may be made to yield data on the continuing type of lightning discharge.

Production and Application of Light

42-97—The Carbon Arc—a Valuable Industrial Tool; *W. C. Kalb (A '13, F '40). 15 cents.* The versatility of the carbon arc as a source of both visible and invisible radiation is shown to be due, in part, to the three basic types of operation to which it is adapted and also to the fact that the character of its energy emission can be modified by changes in core composition. It is used, in its various forms, for many photochemical and irradiation processes, some of which require specific bands of ultraviolet radiation or close reproduction of the effects of natural sunlight. The carbon arc is preferred in other instances because the optical requirements of the application necessitate a light source of small area and extreme brilliancy. Several industrial and commercial uses are cited together with the characteristics which give preference to the carbon arc as a source of radiation.

Protective Devices

42-90—Factors Which Influence the Behavior of Directional Relays; *T. D. Graybeal (A '38). 30 cents.* Very little material dealing with the factors (such as network dissymmetries) which lead to incorrect operation of directional relays has appeared in the technical literature. Practical experience has been the guide as to the relative merits of the 12 possible connections which utilize either line-to-neutral or line-to-line voltages and line currents or the differences of line currents to actuate the relay elements. In this paper a graphical method for analyzing directional relay operation is developed utilizing circle diagrams and symmetrical components, and the method is applied to general cases to ascertain the effects of network dissymmetries. Since the relay volt-ampere expressions in terms of symmetrical components are too complicated to show the relative merits of the 12 connections, the expressions also are given in terms of the modified symmetrical components introduced by Edith Clarke and now widely used in network-analyzer studies of unbalanced faults. Circle diagrams based upon these modified components show conclusively that the ordinary 90-degree, 30-degree, and 60-degree connections are more free from disturbing influences than the other nine and, therefore, give more reliable operation in most practical applications of directional relays. The particular connection which will be most reliable at any given location can be determined by the methods given here when the constants of the power network are known.

PERSONAL ● ● ● ●

H. W. Bibber (A'21, M'30) professor of electrical engineering, Ohio State University, Columbus, has been appointed professor of electrical engineering and head of the division of engineering at Union College, Schenectady, N. Y. He was born March 12, 1899, at Gloucester, Mass., and was graduated from Massachusetts Institute of Technology in 1920 with the degree of bachelor of science in electrical engineering. During 1920–21 he was an MIT exchange instructor in electrical engineering at the École Centrale des Arts et Manufactures, Paris, France, and from 1921 to 1923 he was an instructor in electrical engineering at Massachusetts Institute of Technology, Cambridge, and a part-time instructor at the engineering school, Harvard University, Cambridge, Mass. In 1923 he joined the International General Electric Company, Schenectady, N. Y., as office engineer of apparatus sales and in 1924 was transferred as sales engineer to the company's office in Tokyo, Japan. In 1926 he became manager of the company's office in Osaka, Japan, returning in the latter part of that year to Tokyo to work on turbogenerator sales. From 1927 to 1929 he was in charge of Russian business at the company's Schenectady office and in 1929 he became application engineer, central-station engineering department, General Electric Company, Schenectady, N. Y. In 1932 he was appointed associate professor of electrical engineering at Ohio State University, later becoming professor of electrical engineering. Since 1932 he also has carried on consulting engineering practice. For the year 1940–41 he served as chairman of the AIEE committee on Student Branches. He is also a member of the Society for the Promotion of Engineering Education, Société Françaiṣ des Électriciens, Eta Kappa Nu, Tau Beta Pi, and Sigma Xi.

F. R. Phillips (M'27) president of the Philadelphia Company, Pittsburgh, Pa., and subsidiaries, has become chairman of the board of directors. He will continue as president of the Kentucky, West Virginia Gas Company, and the Pittsburgh Railways Company, but has resigned as president of other subsidiaries. He was born at Cleveland, Ohio, October 29, 1876. In 1894 he was employed in the engineering department of the Cleveland (Ohio) City Railway Company and in 1903 when that company and the Cleveland Electric Company were consolidated, he was appointed assistant master mechanic. From 1904 to 1906 he was master mechanic with the Cincinnati, Newport, and Covington Light and Traction Company, and in 1906 he was appointed chief engineer of the Michigan United Railways Company. In that year he became design engineer for the Ohio Brass Company, Mansfield, and in 1908 he became chief engineer, United Light and Traction Company, Mich. He joined the Pittsburgh Railways Company

in 1910 as superintendent of equipment, in 1923 becoming acting general manager. In 1926 he was appointed vice-president and general manager of the Duquesne Light Company, Pittsburgh, Pa., and in 1928 he became, in addition, vice-president of the Equitable Gas Company. He was appointed senior vice-president of the Philadelphia Company and president of the company's subsidiaries in 1929. In 1931 he was made president of the Philadelphia Company, retaining his position as president of the subsidiaries.

William Kelly (F'25) president, Buffalo, Niagara and Eastern Power Corporation, Buffalo, N. Y., has been elected president of the Buffalo Niagara Electric Corporation. He was born January 8, 1877, at New York, N. Y., and was graduated from the United States Military Academy in 1899. He was in charge of the United States Army seacoast defense corps from 1899 to 1913, acting in addition as assistant engineer commissioner of the District of Columbia from 1906 to 1910. He was assistant to the chief engineers, United States Army, Washington, D. C., from 1913 to 1917 and after a period of military service, he became chief engineer for the Federal Power Commission in 1920. During 1925–26 he was director of engineering of the National Electric Light Association, New York, N. Y. In 1926 he became vice-president of engineering and operation, Buffalo, Niagara, and Eastern Power Corporation and in 1933 he was elected president and director of the company. He is currently serving as president and director of several power companies in the state of New York. He is also a member of the American Society of Civil Engineers, the American Society of Mechanical Engineers, and the American Association for the Advancement of Science.

R. H. Hughes (A'20, F'41) vice-president and general manager, Manhattan area, New York (N. Y.) Telephone Company since 1941, has become vice-president and general manager of the company's recently consolidated Manhattan–Bronx–Westchester area. He was born April 23, 1891, Decatur, Ala., and received the degree of bachelor of engineering from Vanderbilt University in 1913. In that year he joined the engineering department of the Louisville and Nashville Railroad, Louisville, Ky., and in 1914 was employed by the New York Telephone Company as a student engineer. He became local trunk engineer in 1925, and plant extension engineer and assistant vice-president in 1927. In 1939 he was appointed vice-president and general manager of the company's Bronx-Westchester area. **C. R. Fischel** (M'38) former engineer, outside plant and transmission department, Bronx–Westchester area, has been appointed staff engineer. He was employed by the company from 1913 to 1924, except for an interval of military service 1917–19. He joined the American Telephone and Telegraph Company, New York, N. Y., in 1924, returning in 1928 to the New York Telephone Company.

L. A. Grettum (A'24, M'41) vice-president and general manager, Eastern Oregon Light and Power Company, Baker, Ore., has been elected president of the company. He will retain the position of general manager. He was born August 30, 1901, in Duluth, Minn., and was graduated in 1923 from the University of Minnesota with the degree of bachelor of science in electrical engineering. In 1923 he joined the Mississippi Valley Public Service Company, Winona, Minn., as junior engineer, later becoming chief engineer. He became operating manager of the Eastern Oregon company in 1933. He is a member of Eta Kappa Nu and a past president of the Northwest Electric Light and Power Association.

R. D. Cleaves (A'40) former salesman, Allis-Chalmers Manufacturing Company, Pittsburgh, Pa., has joined the transformer sales engineering staff of the Line Material Company with headquarters in Des Moines, Iowa. **O. L. Riggs** (A'21, M'29) former sales manager, American Electric Service and Maintenance Company, Springfield, Mass., also has joined the transformer sales engineering staff of the Line Material Company with headquarters in Springfield.

J. D. Wood (A'19, M'27) president and chief engineer, Roller-Smith Company, Bethlehem, Pa., has resigned as president in order to devote his time as chief engineer to engineering co-ordination and testing. He joined the company in 1928 as assistant to the chief engineer, in 1932 became head of the engineering department, and in 1938 was elected president.

C. A. Mayo (A'13) manager since 1933 of the Eastern Massachusetts Electric Company, Salem, Mass, has been appointed manager of the Salem Gas Light and Salem Electric Lighting companies, of which he has been assistant manager. He will continue to manage the Eastern Massachusetts company, which he joined in 1931 as assistant manager.

H. M. Patterson (A'37, M'40) former electrical engineer, Copper Wire Engineering Association, Washington, D. C., who became district engineer, sales division, Anaconda Wire and Cable Company, New York, N. Y., has been transferred to the company's Atlanta office as district engineer.

O. E. Eckert (M'35) general manager, Board of Water and Light Commissioners, Lansing, Mich., has been appointed a member of a state defense council subcommittee on engineering to deal with engineering problems brought about by the war and to participate in postwar planning.

T. O. Moloney (A'12, M'21) chairman of the board, Moloney Electric Company, St. Louis, Mo., was recently honored by the National Electrical Manufacturers Association in recognition of 50 years of continuous service in the electrical manufacturing industry.

E. A. Roberts (A'17, M'20) former consulting engineer of the firm, Fisk and Roberts, Jersey City, N. J., has been appointed assistant director, division of local transport, Office of Defense Transportation, Washington, D. C.

L. M. Shadgett (A'24, M'31) vice-president, Georgia Power Company, Athens, has been appointed a member of the public utilities committee of the Georgia Defense Council, representing the electric utilities of the state.

A. E. Snowden (Enrolled Student) Carnegie Institute of Technology, Pittsburgh, Pa., has been awarded a fellowship by the Charles A. Coffin Foundation to study the design of variable, smooth-model transmission lines at Carnegie Institute.

A. H. Taylor (A'19) head physicist, Naval Research Laboratory, Anacostia, D. C., has been awarded the Medal of Honor of the Institute of Radio Engineers in recognition of his contributions to radio communication.

J. W. Clarke (A'37) manufacturers' representative, Chicago, Ill., has been appointed sales and engineering representative of Dunco relays and timing devices for Struthers Dunn, Inc., Philadelphia, Pa.

G. A. Fowles (A'37) Pennsylvania Power and Light Company, Allentown, has been appointed sales engineer, synthetic sales division, B. F. Goodrich Company, Akron, Ohio.

S. P. Foster (M'34) valuation engineer, Georgia Power Company, Atlanta, has become electrical engineer, electrical department, for the Austin Company, engineers and builders, Houston, Tex.

E. W. Kimbark (A'27, M'35) assistant professor of electrical engineering and acting chairman of the department, Northwestern University, Evanston, Ill., has been made associate professor.

L. L. Edgar (A'12) vice-president, Boston (Mass.) Edison Company, has been appointed corporate vice-president. He has been with the company since 1911.

OBITUARY • • • •

Alex Dow (A'93, M'95, F'13, HM'37) chairman of the executive committee, Detroit (Mich.) Edison Company, died on March 22, 1942. He was born April 12, 1862, in Glasgow, Scotland, and although he received no formal technical education, he held the honorary degrees of master of engineering (1911) and doctor of engineering (1924) from the University of Michigan, and doctor of science (1936) from the University of Detroit. In 1882

he came to the United States and in 1895 became a United States citizen. From 1882 to 1888 he was employed by the Baltimore and Ohio Railroad and the Baltimore and Ohio Telegraph Company. In 1888 he was employed as installation electrician by the Brush Electric Company, Chicago, Ill., becoming district engineer in charge of the Chicago office 1889. He took charge of the design and construction of the first public lighting plant of the city of Detroit in 1893. In 1896 he became vice-president and general manager of the Edison Electric Illuminating Company of Detroit, continuing as vice-president of the successor company, the Detroit Edison Company, until 1913, when he became president. He held that position until 1940, when he retired to become chairman of the executive committee. He was engineer member of the Detroit Board of Water Commissioners 1916–21 and 1925–27. In 1935 he received the AIEE national prize for the best paper on public relations, "On the Schooling of Engineers." He was awarded the 1936 AIEE Edison Medal for "outstanding leadership in the development of the central-station industry and its service to the public." He was also a member and honorary member of the American Society of Civil Engineers and American Society of Mechanical Engineers and past president of the latter, charter member and past president of the Detroit Engineering Society (now the Engineering Society of Detroit), member of the Institution of Electrical Engineers, and an honorary member of the Institution of Mechanical Engineers, both of Great Britain.

Charles Francis Harding (A'06, M'12, F'14) head of the school of engineering, Purdue University, Lafayette, Ind., died on April 13, 1942. He was born at Fitchburg, Mass., September 11, 1881, and was graduated in 1902 from Worcester Polytechnic Institute, having received the degree of electrical engineer from that institution in 1910. After working in the testing department of the General Electric Company, Schenectady, N. Y., he joined the Worcester and Southbridge Railway Company, Worcester, Mass., as an electrical engineer in 1902. During 1904–05 he was with the D. and W. Fuse Company, Providence, R. I., as electrical engineer in charge of testing and research. In 1905 he went to Cornell as acting assistant professor of electrical engineering and the following year he was an assistant electrical engineer for Stone and Webster, Boston, Mass. In 1908 he became professor of electrical engineering and director of the electrical laboratories at Purdue University where he was responsible for the development of one of the few large high-voltage laboratories located at educational institutions. Since that time he had also been a consulting engineer. He served on a number of AIEE committees, was chairman of the committee on Student Branches from 1918 to 1923, and was a vice-president of the Institute from 1936 to 1938. He was also a member of Sigma Xi, Tau Beta Pi, and the Society for the Promotion of Engineering Education. He was the author of two books, coauthor of another, and had published a number of technical articles.

Francis Patrick Quigley (M'33) since 1941 lieutenant commander, United States Naval Reserve, Bureau of Ships, Navy Department, Washington, D. C., died on March 22, 1942, as the result of an accident. He was born July 30, 1896, at Atlantic City, N. J., and received the degree of bachelor of science in electrical engineering in 1923 from the University of Pennsylvania. During 1923–24 he was employed as assistant designer in the transmission and distribution design division, Philadelphia (Pa.) Electric Company. From 1924 to 1926 he was construction engineer and foreman, Atlantic City (N. J.) Electric Company, a subsidiary of the American Gas and Electric Company. From 1926 to 1927 he was associated with Frank J. Pedrick and Son as office manager and salesman, and from 1927 to 1928 he was construction engineer for United Engineers and Constructors, Inc. He was consulting electrical engineer from 1928 to 1932. After serving as engineer with the Federal Power Commission, he became liaison officer in the procurement division of the United States Treasury Department with headquarters in Denver, Colo., in 1936. He later became electrical engineer, Rural Electrification Administration, Washington, D. C., and in 1939 became senior engineer, power division, Federal Emergency Administration of Public Works, Washington, D. C. He was also a member of the American Society of Naval Engineers.

Marion Penn (M'21, F'35) general manager, electric department, Public Service Electric and Gas Company, Newark, N. J., died March 29, 1942. He was born May 5, 1890, at Humboldt, Tenn., and was graduated in 1911 from Purdue University with the degree of bachelor of science in electrical engineering. From 1911 to 1914 he was employed in the testing department of the General Electric Company, Schenectady, N. Y., and from 1914 to 1917 he was assistant division superintendent, Public Service Electric Company of New Jersey, Elizabeth. After an interval of military service, 1917–19, he returned to the Public Service company as plant engineer in Newark. During 1920–21 he was superintendent of the company's Essex Power Station, in 1921 he became superintendent of the Marion Power Station, and during 1925–26 he held a similar position at the Kearney Power Station. In 1926 he became general superintendent of generation for the company, and in 1935 he was made general manager of the electric department. In 1941 he was appointed a director of the Public Service Corporation of New Jersey. He was also a member of The American Society of Mechanical Engineers.

George A. Booth (A'13) who retired in 1940 as manager, Andersen, Meyer and Company, Ltd., Tientsin, China, died February 18, 1942. He was born March 12, 1886, in Philadelphia, Pa., and received the degree of bachelor of science in electrical engineering from the University of Colorado in 1908. In that year he joined the Spokane and Inland Empire Railway Company to do station operation and meter work, and in 1911 he became design engineer for the British Columbia Railway Company, Vancouver, B. C., remaining until 1919 when he went to China as professor of electrical engineering at Tongshan Engineering College. In 1922 he went to Harbin, Manchuria, where he was engaged to erect and operate an electrical power plant at Fuchitien. In 1929 he joined Andersen, Meyer and Company with headquarters in Mukden, China, in 1934 becoming manager of the company's Tientsin office. After his retirement on account of ill health in 1940, he lived in California.

Horace Whittle (A'20) of the apparatus development department, Bell Telephone Laboratories, New York, N. Y., died on February 18, 1942. He was born July 25, 1896, at Philadelphia, Pa., and received the degree of bachelor of science in electrical engineering from the University of Pennsylvania in 1918. In 1919 he joined the engineering department of the Western Electric Company, New York, N. Y., which became a part of Bell Telephone Laboratories in 1925, to work on the design and development of transformers. He was later made responsible for transformer work and in 1929 he was transferred to work on the development of filters and networks. More recently he was engaged in the development of transmission apparatus. He held a number of patents on transformer and transmission network equipment. He was also a member of Eta Kappa Nu.

Cameron Dewitt Jarvis (A'11) retired telephone engineer of the New England Telephone and Telegraph Company, Boston, Mass., died March 6, 1942. He was born September 16, 1870, near St. Thomas, Ont., and attended Collegiate Institute, Hamilton, Ont. From 1892–94 he was employed by the Bell Telephone Company of Canada, Toronto, Ont. and in 1894 he joined the electrical engineering department of the New England Telephone and Telegraph Company, in 1910 becoming assistant to the chief engineer of plants. He was later engineer for that company and was active in the development of electrical methods and devices for the telephone art.

MEMBERSHIP • •

Recommended for Transfer

The board of examiners, at its meeting on April 23, 1942, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Cone, D. I., transmission and protection engineer, Pacific Telephone and Telegraph Company, San Francisco, Calif.
Jones, B. M., planning division engineer, Duquesne Light Company, Pittsburgh, Pa.

Oesterreich, E. W., general superintendent of distribution, Duquesne Light Company, Pittsburgh, Pa.
Smith, M. W., vice-president in charge of engineering, Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.

4 to grade of Fellow

To Grade of Member

Alford, Andrew, head of aerial navigation laboratory International Telephone and Radio Laboratories, New York, N. Y.
Ankele, E. T., general superintendent, Lower Colorado River Authority, Austin, Tex.
Brooks, F. E., assistant vice-president, New York Telephone Company, New York, N. Y.
Charles, D. M., electrical engineer, Reliance Electric and Engineering Company, Cleveland, Ohio.
Connor, W. F., foreman of test, Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Eldred, W. N., assistant to general manager, Heintz and Kaufman, Ltd., South San Francisco, Calif.
Godfrey, C. M., plant supervisor, Chesapeake and Potomac Telephone Company, Washington, D. C.
Herrick, D. C., electrical engineer, General Electric Company, Cleveland, Ohio.
Hesselmeyer, C. T., electrical test engineer, Chicago District Electric Generating Corporation, Chicago, Ill.
Hutson, M. B., electrical engineer, Cressy and Alcus, New Orleans, La.
Immich, H. R., district engineer, Southwestern Bell Telephone Company, Wichita, Kans.
Knight, I. T., electrical engineer, Kansas City Power and Light Company, Kansas City, Mo.
Landwehr, J. H., general building and equipment engineer, Southwestern Bell Telephone Company, St. Louis, Mo.
McMurray, W. K., electrical engineer, St. Joseph Railway, Light, Heat and Power Company, St. Joseph, Mo.
Mermin, John, engineer of power equipment, The Southern New England Telephone Company, New Haven, Conn.
Page, G. R., engineer, Western Electric Company, Baltimore, Md.
Palmer, J. H., head of electric research laboratory, Phelps Dodge Copper Products, Yonkers, N. Y.
Staples, E. B., development engineer, Holtzer Cabot Electric Company, Boston, Mass.
Walker, E. T., instructor, Bliss Electrical School, Takoma Park, D. C.
Wentz, E. C., transformer design engineer, Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Wentz, J. F., high-frequency transmission engineer, Bell Telephone Laboratories, New York, N. Y.

21 to grade of Member

Applications for Election

Applications have been received at headquarters rom the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical District. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before May 1, 1942, or July 31, 1942, if the applicant resides outside of the United States or Canada.

United States and Canada

1. North Eastern

Abbott, F. H. (Member), Fay, Spoflord and Thorndike, Boston, Mass.
Atherton, C. A. (Member), Champion Lamp Works, Lynn, Mass.
Daly, D. F., Colt's Patent Fire Arms Manufacturing Company, Hartford, Conn.
Davis, R. J., General Electric Company, West Lynn, Mass.
Garrett, J. C., General Electric Company, Lynn, Mass.
McKeefery, W. J., Jr., General Electric Company, Schenectady, N. Y.
Prud'homme, E. S., General Electric Company, Schenectady, N. Y.
Richter, H., U. S. Signal Corps, Royal Electric Company, Pawtucket, R. I.
Thompson, P. M., General Electric Company, Schenectady, N. Y.

2. Middle Eastern

Austin, E. H. (Member), E. I. du Pont de Nemours and Company, Inc., Wilmington, Del.
Boghosian, E., United States Navy, Philadelphia, Pa.
Broschart, C. B., The Bradley Company, Philadelphia, Pa.
Brown, R. L. (Member), Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Cunningham, J. C., Jr. (Associate re-election), Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Devine, E. H., C. H. Wheeler Manufacturing Company, Philadelphia, Pa.
Fitzgerald, D. J., Consolidated Gas Electric Light and Power Company, Baltimore, Md.
Grigg, J. C., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Hardinghaus, L., Ohio Inspection Bureau, Cincinnati, Ohio.
Juliana, W. J., Westinghouse Electric and Manufacturing Company, Lima, Ohio.
Knefel, F. B., Bucyrus Telephone Company, Bucyrus, Ohio.
Lordo, A. R.,Westinghouse Electric and Manufacturing Company, Sharon, Pa.
McWhirk, T. H. (Associate re-election), United States Navy, Shelby, Ohio.
Meehan, J. R. (Member), Federal Public Housing Authority, Washington, D. C.
Miller, R. E., Bradford Electric Company, Bradford, Pa.
Morgan, M. H., Jr. (Member), Carnegie-Illinois Steel Corporation, Youngstown, Ohio.
Peck, J. C., Westinghouse Electric and Manufacturing Company, Mansfield, Ohio.
Rodgers, W. S., Philadelphia Electric Company, Philadelphia, Pa.
Ryden, E. H. (Associate re-election), Bryant Heater Company, Cleveland, Ohio.
Scott, A. H., National Bureau of Standards, Washington, D. C.
Selvage, C. N., Standard Oil Company of New Jersey, Canton, Baltimore, Md.
Shollenberger, R. R., Elliott Company, Ridgway, Pa.
Smith, J. R., Pennsylvania Transformer Company, Pittsburgh, Pa.
Smith, W. O., Westinghouse Electric and Manufacturing Company, Washington, D. C.
Somerville, W. K., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Walter, J. C. (Member), RCA Manufacturing Company, Camden, N. J.
Weaver, A. R. (Associate re-election), Graybar Electric Company, Toledo, Ohio.
Woolley, S. L. (Member), Duquesne Light Company, Pittsburgh, Pa.

3. New York City

Bhattacharjee, S. B., 1687 Park Avenue, New York, N. Y.
Deutch, M. J. (Member), Sofina, Limited, New York, N. Y.
DiCesare, G. E. (Member), J. G. White Engineering Corporation, New York, N. Y.
Dock, A. F. (Associate re-election), New York Telephone Company, New York, N. Y.
Edelstein, S. E., Jr., United States Naval Reserve, U.S.S. Melville, N. Y.
Ellefsen, O. S., American Gas and Electric Service Corporation, New York, N. Y.
Endres, W. G., The Teleregister Corporation, New York, N. Y.
Grazda, E. E., Lincoln Walsh, Consulting Engineer, Elizabeth, N. J.
Hofheimer, R. W., Circle Wire and Cable Corporation, Maspeth, Long Island, N. Y.
Marr, G. M. (Member re-election), C. C. Galbraith and Son, New York, N. Y.
Maurushat, J., Jr., Bell Telephone Laboratories, Inc., New York, N. Y.
Ortiz, J. V., Francisco and Jacobus, Engineers and Architects, New York, N. Y.
Petermann, G. A., American Gas and Electric Service Corporation, New York, N. Y.
Savilla, D. A., Federal Shipbuilding and Dry Dock Company, Kearny, N. J.
Semel, M., Pilot Radio Corporation, Long Island City, N. Y.
Seugling, R. J., Public Service Electric and Gas Company, Newark, N. J.
Siling, G. (Member), Fire Department, New York, N. Y.
Strain, M., Sperry Products, Incorporated, Hoboken, N. J.
Strom, R. L., Gibbs and Cox, Inc., New York, N. Y.
Westlake, P. R., 476 Beardsley Avenue, Bloomfield, N. J.
Wheeler, J. W., Ward Leonard Electric Company, Mount Vernon, N. Y.
Wigington, W. H., Jr., United States Army Signal Corps, Fort Monmouth, Red Bank, N. J.

4. Southern

Brice, W. E., Public Works of Navy Department, New Orleans, La.
Dent, S. H. (Member), General Engineering Company, Jacksonville, Fla.
Drake, J. L., Barnard, Godat and Heft, New Orleans, La.
Miller, M., District Material Office, Naval Operating Base, Norfolk, Va.
Parnell, T. J., Wilson Dam Hydro Plant, Wilson Dam, Ala.
Perry, J. F., Department of Electricity, Clarksville, Tenn.
Rabb, G. E., United States Engineers Office, Jacksonville, Fla.
Whitehouse, T. S. (Associate re-election), Tennessee Valley Authority, Knoxville, Tenn.

5. Great Lakes

Bauer, F., Detroit Edison Company, Detroit, Mich.
Benckenstein, R. J., General Electric Company, Fort Wayne, Ind.
Brockmeyer, H. R., Harnischfeger Corporation, West Milwaukee, Wis.
Christensen, C. P., Illinois Bell Telephone Company, Chicago, Ill.
Dunn, C. M., General Electric Company, South Bend, Ind.
Engelbrecht, W. J., Detroit Edison Company, Port Huron, Mich.
Gomersall, J. R. (Member), McGraw Electric Company, Elgin, Ill.
Kramer, L. A., The Commonwealth and Southern Corporation, Jackson, Mich.
Marco, F. (Member), Comar Electric Company, Chicago, Ill.
McGaw, R. L. (Member), The Commonwealth and Southern Corporation, Jackson, Mich.
Nickerson, O. (Associate re-election), General Electric Company, Chicago, Ill.
Nicolson, E. L. (Associate re-election), General Electric Company, Chicago, Ill.
Porskievies, A. J. (Fellow re-election), Vickers, Inc., Detroit, Mich.
Proszek, M. F., Public Lighting Commission, Detroit, Mich.
Segar, S. G., Commonwealth and Southern Corporation, Jackson, Mich.
Shydlowsky, W. J., Public Lighting Commission, Detroit, Mich.
Smith, J. C., Public Service Company of Northern Illinois, Chicago, Ill.
Steinberger, E. B., Allis-Chalmers Manufacturing Company, Milwaukee, Wis.
Vielhauer, E. U., St. Paul Foundry Company, St. Paul, Minn.

6. North Central

Dubbe, E. C., South Dakota State College, Brookings, S. D.
O'Brien, E. J., University of North Dakota, Grand Forks, N. D.

7. South West

Davidson, T. R., Texas State Board for Vocational Education, Austin, Texas.
Griswold, N. D. (Member), Dow Chemical Company, Freeport, Tex.
Mercer, H. H., Fraser-Brace Engineering Company, Welden Springs, Mo.
Shaull, L. K., Union Electric Company of Missouri, Webster Groves, Mo.
Wieting, J. H., Houston Shipbuilding Corporation, Houston, Tex.
Yonley, T., Fairbanks-Morse and Company, Kansas City, Mo.

8. Pacific

Barbano, R. J., United States Naval Reserve, Campbell, Calif.
Olmsted, E. G., Department of Water and Power, Los Angeles, Calif.
Pederson, A C., Kelman Electric and Manufacturing Company, Los Angeles, Calif.
Savage, P. L. (Associate re-election), General Electric Company, Los Angeles, Calif.
Thompson, V. M., Quality Electric Company, Ltd., Los Angeles, Calif.

9. North West

Brown, J. S., Boeing Aircraft Company, Seattle, Wash.
Carter, E. T., Boeing Aircraft Company, Seattle, Wash.
Cowling, C., Public Utility District Number One, Clallam County, Wash.
Franzel, R. T., Boeing Airplane Company, Seattle, Wash.
Grant, C. G., United States Army, Vancouver Barracks, Wash.
Patterson, T. S., City Lighting Department, Seattle, Wash.
Powers, A. B., 13th Naval District, Seattle, Wash.

10. Canada

Cleaver, J. J., United Farmers Co-operative Company, Ltd., Toronto, Ont.
Clucas, J. R., Canadian Westinghouse Company, Ltd., Hamilton, Ont.
Doran, J. P. (Member), Bell Telephone Company of Canada, Toronto, Ont.
Knights, K. R., Canadian Westinghouse Company, Ltd., Hamilton, Ont.
Sperring, F. T., Burrard Dry Dock Company, Ltd., North Vancouver, B. C.

Total, United States and Canada, 111

Elsewhere

Arizmendi, J. A. N., Puerto Rico Water Resources Authority, Ponce, P. R.
Babcock, J. H., Headquarters Hawaiian Department, Fort Shafter, T. H.
Collins, R. J. (Member), Radio Corporation Pty. Ltd., Melbourne, Australia.
Desai, N. D., Surat Electricity Company, Ltd., Surat, India.
Franceschini, M. R., Utilization of Water Resources, Yauco, Puerto Rico.
Lake, R. N., General Electric Company, Ltd., Witton, Birmingham, England.

Total, elsewhere ,6

Extensive Postwar Planning Outlined by National Resources Planning Board

National planning now under way by the National Resources Planning Board for the postwar period has been outlined in a report recently transmitted to Congress by President Roosevelt. The broad objectives of this planning are stipulated to be "full employment, higher living standards, and economic security." Excerpts from the report are presented here; contributions to the "Letters to the Editor" columns on this important topic are invited.

Stressing "a greater freedom for the American people" as the ultimate aim of all postwar planning efforts, the Board—in its introduction to the report—says: "Great changes have come in our century, with the industrial revolution, the rapid settlement of the continent, the development of technology, the acceleration of transportation and communication, the growth of modern capitalism, and the rise of the national state with its economic programs. Too few corresponding adjustments have been made in our provisions for human freedom. In spite of all these changes, that great manifesto, the Bill of Rights, has stood unshaken 150 years. And now to the old freedoms we must add new freedoms and restate our objectives in modern terms.

NEW "FREEDOMS"

"*Freedom of speech and expression, freedom to worship, freedom from want,* and *freedom from fear*—these are the universals of human life. Any new declaration of personal rights, any translation of freedom into modern terms applicable to the people of the United States here and now must include:

"1. *The right to work,* usefully and creatively through the productive years.

"2. *The right to fair pay,* adequate to command the necessities and amenities of life in exchange for work, ideas, thrift, and other socially valuable service.

"3. *The right to adequate food, clothing, shelter, and medical care.*

"4. *The right to security,* with freedom from fear of old age, want, dependency, sickness, unemployment, and accident.

"5. *The right to live in a system of free enterprise,* free from compulsory labor, irresponsible private power, arbitrary public authority, and unregulated monopolies.

"6. *The right to come and go, to speak or to be silent,* free from the spyings of secret political police.

"7. *The right to equality before the law,* with equal access to justice in fact.

"8. *The right to education,* for work, for citizenship, and for personal growth and happiness.

"9. *The right to rest,* recreation, and adventure; the opportunity to enjoy life and take part in an advancing civilization.

"These rights and opportunities we in the United States want for ourselves and for our children now and when this war is over. They go beyond the political forms and freedoms for which our ancestors fought and which they handed on to us, because we live in a new world in which the central problems arise from new pressures of power, production, and population, which our forefathers did not face."

OBJECTIVES

Summarizing the "central objectives" of postwar planning, the report says:

"We must plan for full employment, for maintaining the national income at 100 billion dollars a year, at least, rather than to let it slip back to 80, or 70, or 60 billion dollars again. In other words, we shall plan to balance our national production–consumption budget at a high level with full employment, not at a low level with mass unemployment.

"We must plan to do this without requiring work from youth who should be in school, the aged who should be relieved if they wish it, and women who choose to make their contribution in the home, and without asking anyone to work regularly in mines, factories, transportation, or offices more than 40 hours a week or 50 weeks a year, or to sacrifice the wage standards which have been set.

"We must plan to decentralize postemergency activities as far as possible; to use to the utmost our system of modified free enterprise with its voluntary employment, its special reward for effort, imagination, and improvement, its elasticity and competition; and to advance co-operatively under national and governmental leadership.

"We must plan to enable every human being within our boundaries to realize progressively the promise of American life in food, shelter, clothing, medical care, education, work, rest, home life, opportunity to advance, adventure, and the basic freedoms.

"We must plan to make up-building America the keynote of the postwar program, including both development of our national resources adding to the national estate, and service activities, which will increase the vitality, health, skill, productivity, knowledge, and happiness of the American people, and thus together end unemployment and add to our wealth and well-being."

PLANS AND PROGRAMS

Discussing plans and programs, the report says that "the Board will serve as a clearing house to gather ideas and plans, to stimulate appropriate independent action by other public and private agencies, to bring together individuals who are interested in harmonizing their views, and to furnish the President and the Congress with information and assistance on the formulation of policies on these matters.

"The elected representatives of the people will, of course, make the decisions on policies and methods for meeting the problems of the postdefense period. The Congress has already provided appropriations for the inauguration of needed studies by this Board and for the preparation of postwar plans by various other agencies in the executive branch. With full public discussion and appraisal, the Congress will determine the appropriate policies and how they shall be put into action.

"From the statement of objectives in the preceding section, the lines of action to be explored and developed as elements of a postwar program are clear. They include:

"1. Plans for demobilization:
(a) For men—jobs, retraining, and dismissal wages.
(b) For machines—retooling and conversion.
(c) For controls—maintenance as long as needed.

"2. Plans with private enterprise:
(a) Encouraging initiative: production; services.
(b) Consumer market analysis.
(c) Industrial location and plant.
(d) Government aids and co-operation.

"3. Plans for public activities:
(a) Improvements and facilities.
(b) Services.

"4. Plans for security—old age, unemployment, public assistance, family allowances, and special aids.

"5. Plans affecting labor force.

"6. Plans for financing and fiscal policies.

"7. Plans for state, city, and regional participation.

"8. Plans in the international scene—with particular reference to their domestic implications."

The status of plans for demobilization, private enterprise, and public activities were summarized in the report (in part) as follows.

PLANS FOR DEMOBILIZATION

"The demobilization of the armed forces of the nation must be as carefully planned, as their recruitment. The Selective Service Act of 1940 directed that arrangements be made for the return to previous employment of all men called for service with the armed forces of the government. A re-employment division in the Selective Service System directs the work of re-employment committees in various localities who co-operate in replacing selectees released from service. This division is interested in planning for the future demobilization of the armed forces and also in studying potential employment demands in the postwar period.

"Much more thought should be given to the problem of the timing of demobilization than has been hitherto thought necessary. The defense and war programs have involved tremendous efforts to develop new skills and trained personnel for a great variety of industrial activities. The same procedures might be adapted to preparing men, while still in the armed forces, to assume jobs in industry when they are released from the Army or Navy.

"Studies are being made by the Bureau of Labor Statistics of demobilization experience after November 11, 1918; of trends in productivity per man-hour; and of the size, age and composition of the labor force. Data collected by the Bureau on labor force requirements for various kinds of work will be useful in projecting training and vocational needs in the postwar economy. Perhaps the idea of a 'dismissal wage or allowance' for those employed in industry is also applicable to demobilized men from the armed forces.

"This time it is questionable whether we should be in such haste. Our total war effort now will bulge much larger in the national economy than it did in 1918. Any hasty curtailment of war production may have severe repercussions throughout our entire economy. Indeed, it is conceivable that it would be less wasteful to continue some war-production even after the immediate demand is ended rather than to halt precipitately that production. If we are going to retrain men from the armed forces or from defense industries for peacetime jobs, we might appropriately consider retooling or converting our machines and plants to produce peacetime goods.

"Not alone would the immediate worker in war industries thrown out of work be affected by hasty industrial demobilization, but transportation workers and the suppliers of raw materials for war production would also be affected. Their income would drop and hence their consumer demands be lessened. While we may want to give priority in the postwar period to consumer goods rather than defense goods, industrial demobilization might still proceed gradually.

"The Bureau of Foreign and Domestic Commerce of the Department of Commerce is giving attention to distortions in productive activity occasioned by the war and defense programs and the possible transitional requirements in both consumer and producer goods. The possible extent of a "back-log" of consumer demand following the immediate cessation of the defense program is being examined.

"The mobilization of our resources has involved the establishment of government controls over allocations of materials, prices, and priorities to meet war problems. The demobilization of our war effort and the shift from full employment on defense to full employment in peace will involve some of the same kinds of problems. The adaptation of the government controls to these ends must be planned ahead.

"Plans can be laid now in order that we may have an orderly and economical procedure for demobilization. Even as the attention of a large number of Army officers and civilians should in peacetime be given to the problems of wartime industrial mobilization, so in time of war production we must think about demobilization for peacetime production.

PLANS WITH PRIVATE ENTERPRISE

"Private enterprise must be encouraged to think in terms of a high-level economy. The industrial opportunities for tomorrow can be of unprecedented magnitude. Private industry must be prepared to participate in these opportunities.

"The requirements of the war program in terms of battleships, airplanes, tanks and guns are relatively simple when compared to the multifarious demands of the American consumer in peacetimes. But some gauge of that demand can be discovered to assist those who seek to gear production to a peacetime market.

"The Board has built up a fund of knowledge concerning the habits of the American consumer and is now engaged, with the co-operation of various Federal agencies, in a re-examination of those data and their meaning in terms of various levels of national income or different distribution of income. The 1935–36 figures reflect consumer demands with a national income around 60 billions a year. What changes should be expected with a national income of 100 billion or 110 billion? If the lowest income group—the third of the nation with incomes under $780 a year—were to receive twice that amount, what kinds of changes in consumer demand should be anticipated? These questions and a long series of similar variations are being explored by the Board in the hope that such data will indicate the required needs in raw materials, productive plant, energy resources, transport facilities, and labor force. We shall have to estimate the needed additions to private capital plant to meet consumer demands and the levels of national investment required to meet general public needs and to insure full employment.

"The Bureau of Labor Statistics is making consumer-spending studies through sampling techniques as a means of obtaining current data reflecting trends in consumer purchases as well as effects of the defense and war programs. These studies indicate potential demands for all kinds of goods when priority restrictions are removed. Similar studies in rural areas are being made by the Bureau of Home Economics and the Bureau of Agriculture Economics in the Department of Agriculture.

"It would be appropriate if the tentative beginnings made by the Bureau of Foreign and Domestic Commerce in studying the volume of private investment in productive plant could be expanded, in co-operation with the Department's Business Advisory Council, to aid private enterprise in the formulation of long-range budgets of capital plant expansion to meet expanded consumer needs and help maintain a high-output peacetime economy.

"A major change in the distribution of industry may result from the location of new war industries. At the request of the President the Board set up a special staff to study problems of industrial location and to assist the plant site board and other agencies making decisions on these matters with information and advice. The progress of that work . . . shows that the long-range influence of new defense plants will largely depend on the adaptability of plant, machines, and industrial leaders to the market opportunists of the postwar era. If regional leadership has the qualities necessary to chart a course for regional development the plant and skills established now in new industrial areas provides a basis for new growth.

"The energies of the staff of the industrial section of the Board are now concentrated on conversion problems and possibilities, but every one concerned, of course, recognizes that the enterprise of private businessmen and industrialists will have to provide the primary impetus to effective conversion of war industries to peacetime production.

"No national resource is more valuable than the quality of its manpower. High among the qualities which are essential for a great nation in the present era of mass production and in the future era of corresponding high consumption is the ability and the skill to plan, to organize, and to co-ordinate men, power, and materials in the accomplishment of defined objectives. This is the function of management. Without it there can be no great enterprise, no great nation, no great people.

"Management, thus understood, is a national resource. It is a resource which is not absent in our nation as our history and institutions testify. None the less, no one can examine the facts without concluding that we have not in the past fully realized the importance of management skills and ability nor taken the most effective steps to discover, develop, or conserve this national resource. In developing broad national policies for the future designed to make full use of our national resources, material and human, particular attention will be given to management as a vital national resource.

"The role of Government in relation to the provision of these new demands on private enterprise will continue, of course, to be an important factor. Government actions have always played a major role in the development of industry and its stabilization. Hamilton's Plan for Manufactures, our patent system, the Homestead Law, the grants of public lands for the construction of the transcontinental railroads, our tariff policies, the 'good roads' movement and its effect on the automobile industry, and most recently the work of the Defense Plant Corporation—these are all examples of government assistance to the free-enterprise system. New forms of assistance and co-operative action between government and business will be needed in the postdefense period.

PLANS FOR PUBLIC ACTIVITIES

"There are many opportunities for government—Federal, state, and local—to aid private business in major fields of activity and investment where only new laws, new procedures, and new funds can unlock the door. Public action must, of course, be planned to meet general public needs. But those needs which are met by private enterprise reduce by just that amount the remaining load on government.

Some of the major possibilities of new activities in production and services . . . include the following:

"*Urban Conservation and Development.* Our obsolete terminal facilities for all modes of transportation—rail, water, highway and air—need simplification, modernization, and reorganization. After the war we can rebuild our housing facilities and really get at the job of eradicating the slum and blighted area from our cities, great and small. A unit of the Board's staff is developing materials on needed steps in government procedures, metropolitan co-operation, land acquisition, etc., to implement new action programs, and in this work is building on the previous reports

of the Board. Procedures are now being worked out for the progressive planning of the many facilities which are required for modern urban living.

"*Rural Works and Land Use.* In rural areas there are corresponding opportunities for new enterprise—conserving our soil, rebuilding and operating our forest resources, developing the range, and opening recreational developments. The land committee of the Board has developed statements of criteria to assist in the evaluation of public work proposals. The Committee's staff is at work measuring the extent of changes in agricultural land use and acreage requirements in order to provide our population with an adequate nutritious diet.

"The Secretary of Agriculture has created an interbureau co-ordinating committee on postdefense programs with representatives from various agencies within the Department of Agriculture. A subcommittee on agricultural–industrial relations is concerned with the influence of future industrial activity upon agricultural production and welfare. Another is studying the problems of maintenance of desired levels of income for agriculture in relation to high levels of domestic consumption and industrial use of farm products. Agriculture has a high stake in the nation's program for industrial activity.

"A second subcommittee within the Department of Agriculture is concerned with the development of a shelf of public works projects to meet the needs of rural areas. For one thing, increased attention will be given to the restoration and development of the physical resources upon which agriculture depends. Soil conservation, flood control, reforestation, irrigation are all required phases of a program to enable the nation to pass on to future generations not a depleted but an enriched soil base. In the second place there is a need for many new and improved public facilities for people in rural areas—public schools, hospitals, and sanitation and recreational facilities. Thirdly, much remains to be done in bringing electric power to the nation's farms and in improving rural housing standards.

"In addition to the interbureau co-ordinating committee in Washington, the Secretary of Agriculture has set up nine regional committees throughout the United States made up of representatives from various agencies of the department. These regional committees will carry on the same kind of work for the region as the national committee and will serve as a link between Washington and state and local planning bodies.

"*Drainage Basin Development.* The success of the Tennessee Valley Authority in building private business in the area which it serves, naturally suggests similar programs for other drainage basins to provide multiple purpose development of their resources. Such programs may provide a way of stimulating both the social and economic progress of large regions or areas in the United States. Many plans already exist for such development, but they need to be tied together and put in orderly programs if they are to be effectuated promptly upon the return of peace. Proposals for the preparation and integration of needed plans for irrigation, navigation, water power, flood control, recreational facilities, industrial cooling water, drainage, pollution abatement and other water use and control developments are included in the statement of the Water Resources Committee.

"*Transportation.* We must not forget that the development and up-building of America has always been closely related to the provision of adequate transportation facilities. We have relied upon transportation as the key to our settlement of the West and to building the nation more than to any other one factor. There is no reason to suppose that we cannot and should not continue to rely upon new major developments in the transportation field after the war to provide a mainspring for other kinds of developmental work throughout the nation.

"The forthcoming report of the Board on national transportation policies provides a basis for further postwar transportation plans . . . New rail facilities, particularly terminals, new highways, new airways and airports, new shipping facilities will all be required with new equipment and operating techniques fitted to the rapid advances in technology.

"Many agencies in the government are directly concerned with these postwar transportation plans. The Public Roads Administration is at work on interregional highway studies and other projects; the Interstate Commerce Commission has many responsibilities in the field. The United States Maritime Commission, which has found its ten-year program for the construction of some 500 merchant vessels enlarged to the construction of 1,400 vessels in three years, is planning to make various studies of the demobilization of emergency shipping construction and the possible place of the United States in international shipping in the postwar world.

"*Energy.* The war is teaching us the importance of conservation and integrated use of our energy resources. Coal, oil, and water power are all parts of a single energizing force for our industries, for heating, for lighting and for other uses. New sources of power may be harnessed by our scientists and inventors. We must plan now to make the most effective use of these resources as energizers of new activities in the postwar period.

"*Programming Public Improvements.* The timing of public activities to reduce the intensity of booms and depressions has long been advocated by economists. Congress adopted the policy in 1931 'to arrange the construction of public works as far as practicable in such manner as would assist in the stabilization of industry and employment through proper timing of such construction.'

"The President has stated repeatedly that we must slow down on expenditures for development projects which are not related to defense in order that our full national energy can be concentrated on the war effort, but he has also pointed out that now is the time to prepare the plans so that the projects which are temporarily 'put on the shelf' or in 'the pantry closet' can be ready when our energies can again be used for the development of our national resources and of our standard of living."

In addition to the statement of objectives and lines of action for postwar planning quoted in part in the preceding paragraphs, which constitutes part I of the published report, part II presents the detailed program of public works with a record of progress on public works planning; and part III includes a series of policy statements prepared by consultants and staff of the Board, on wartime planning for maintaining employment. Trends in national income, employment, and consumption, and surveys for the Federal public works program are shown by tables contained in appendixes. Copies of "National Resources Development, Report for 1942" may be obtained for 55 cents each from the Superintendent of Documents, Washington, D. C.

Radios Go to War

Production of communication equipment needed by the military services is expected to exceed a rate of $125,000,000 a month by the end of the year, according to estimates recently made public by the War Production Board.

The program for this type of war materiel, including that delivered, on order, and yet to be allocated, amounts to approximately $2,000,000,000. About half of the program is for detector equipment; 20 per cent for aircraft and navigation equipment; 20 per cent for tank sets, "walkie-talkies," etc.; and the remainder for telegraph, telephone, and miscellaneous equipment. About 120 set models are included, ranging in cost from $75 to $85,000 a unit, each made according to the most rigid specifications of the Army and Navy.

Every facility—engineering brains, factory supervision, plants, technical "know how"—of the radio manufacturing industry will have to be used in order to produce this tremendous volume of military communication equipment. Some of the facilities are being provided by the conversion of electrical appliance plants, telephone equipment plants, air-conditioning plants, refrigeration plants, and others not normally associated with the radio industry. But the conversion that strikes nearest the average man is that of the manufacturers of home radio receiving sets. The War Production Board ordered that after April 22 there will be no more sets made for civilian use.

CIVILIAN SETS

All sets for civilian demand were made by a group of 55 manufacturers, ranging from companies with complete technical equipment capable of building entire units from raw materials, to companies that only assembled parts supplied by other plants. Feeding the set manufacturers were 250

additional firms that made parts—tubes, capacitors, loud speakers—and another 500 to 1,000 firms that made switches, stampings, screws, and the like.

So far as the 55 set makers were concerned, civilian radios comprised nearly all of their business in 1941. There was some work on military equipment, but it amounted to only an additional $10,000,000, or about 5 per cent of the total volume.

Aside from this relatively small conversion to military work, the first real step toward making the facilities available for use in the war program was taken January 23 when the Consumers Durable Goods Branch of the War Production Board issued an order curtailing by about 40 per cent the production of receiving sets for civilian use. Reductions also were ordered in the output of phonographs and radio-phonograph combinations.

The next step was the stop order by which all of the industry's facilities will be made available for war work and an estimated annual consumption of 70,000 tons of steel, 10,000 tons of copper, 2,100 tons of aluminum, and 280 tons of nickel will be diverted from civilian to military equipment. Provision is made in the order for appeals from manufacturers who desire to continue their limited operations. It has been announced, however, that such appeals will be considered only on a basis of expediting and facilitating war production, with inventories a secondary factor.

What this means to the average man is that the old set will have to do for the duration. There will be some parts and replacements available, and a few new sets but not many. These will come from stocks in the hands of manufacturers and dealers at the time of the limitation order January 23, and from the stock pile of approximately 3,000,000 sets which will have been made before curtailment becomes complete.

MILITARY EQUIPMENT

In converting radio manufacturers to war production, the problem is one of individual plants, rather than one of the industry as a whole. There are several reasons for this. One is the composition of the industry. In it are companies that make nothing else but radio equipment. Other companies in the industry are part of large corporations that also make automobiles, air-conditioning equipment, electrical appliances, and many other products unrelated to radio.

Another factor that makes conversion a complex problem is the make-up of the companies themselves. Some concentrate on making single models while others build a wide variety. But the most important factor is that involving the particular facilities of the plant. Sometimes the Army and Navy and WPB have gone outside the regular radio industry for many types of equipment because other firms are better qualified technically. For instance, the laboratories that make telephone equipment have been given large contracts for certain intricate types of communication materiel.

Of the 55 manufacturers of civilian radio receiving sets, 21 had experience last year making military equipment worth $10,000,000. Contracts worth $500,000,000 have been awarded to set manufacturers so far this year, with about 40 firms sharing the orders. Most of the volume, however, has gone to a few companies, and only 11 companies have booked war business in excess of their 1941 civilian business. That leaves a lot of facility yet to be used for military communication equipment. This will come from plants now holding only small orders and from plants that now are doing no war work. It is expected, however, that a few of the plants that will stop making civilian sets will not get orders to build communication equipment. These plants, with limited technical facilities, probably will turn to assembling, if they are to continue operation. Typical of the kind of work they may find to do is that of assembling gas masks, machine gun clips, first-aid kits, etc. Some of the radio cabinet makers already affected by the curtailment order have used their ingenuity to get orders for making tool kits, medicine cabinets, and other articles requiring skill in wood work.

Subcontracting will spread with the increasing demand for more military equipment. About 10 per cent of the completed sets now are being subcontracted. In the fall of 1941 there were only two subcontractors doing work valued at $5,000,000. On February 1 there were 22 subcontractors of complete sets with orders worth $90,000,000.

The radio on the parlor table resembles only slightly the equipment that the military services need for airplanes, ships, tanks, and air-raid-warning systems. Some of the small models of civilian sets cost as little as $6. The cheapest military receiving set costs about $75. This wide difference in price is caused by the vastly superior quality of the military set. Besides shockproof receiving sets, the military communication systems need such intricate instruments as aircraft locators, altitude finders, direction indicators, and the like.

The tremendous increase in the volume of parts needed to assemble the communication equipment and keep it in service is indicated by the scheduled production of tubes. The output was valued at $6,000,000 in 1940 and $11,000,000 last year. This year, with nearly 100 per cent production for military and essential defense uses, the value may reach $90,000,000—more than an eightfold increase.

Because of the specialized requirements of military communications equipment, some of the parts used by the parlor radios will not be needed, while others will be built to more precise specifications and in greater numbers. Tuning capacitors for military use are more complicated and capable of higher performance, and requirements are well in excess of civilian demand. Antennas are of several types—for receiving broadcast signals, for direction finding, etc.—and hardly as simple in construction as the kind wound around the inside of the parlor console.

Because most military sets are operated by battery or by power units, there will be less demand for transformers used by nearly all home sets. Loud-speakers are not needed in anywhere near the civilian quantity. The Army and Navy use earphones with most of their sets. There will be less demand for tone controls, and more demand for filters. The latter are used to eliminate static disturbances caused by jeeps, motorcycles, tanks and airplanes in which the sets are carried.

Selective Service Registrants to Be Classified by Occupation

An "occupational questionnaire is being sent to every man between 20 and 44 years of age who registered for Selective Service on February 16, 1942, according to an announcement by the United States Employment Service. This occupational registration is being conducted jointly by the United States Employment Service and the Selective Service System.

The questionnaire, which is in two identical parts, one for the Selective Service System and one for the United States Employment Service, asks for information about the registrant's present job, his education, and also asks him to indicate the kind of work for which he considers himself best fitted, whether or not he is presently employed at such work. In addition, it contains a list of 228 different occupations which are important to the war industries, and asks registrants to check any of these in which they have had training or experience and indicate those for which they are best fitted.

The United States Employment offices will examine the occupational questionnaires to determine which men are already qualified or can be quickly trained for work in essential war industries. Those men will then be asked to come to the local United States employment office for an interview.

Workers possessing skills important to war production, who are not working in war industry or in essential civilian activities, but are willing to be trained and transferred to such work, will be given an opportunity to do so.

The purpose of the occupational registration is to provide the Government with a complete occupational inventory of its manpower, in order:

1. To avoid the induction into the armed forces of men who are more urgently needed in war production.

2. To replace workers who are now deferred from military service on occupational grounds whenever possible, with vocational trainees or other qualified persons who, because of age, sex, or other reasons, are not suitable for military service.

3. To speed up war production by promoting the transfer of workers from nonessential to essential work.

Following this first occupational registration, the same questionnaire will also be mailed to men who registered for Selective Service during 1940 and 1941 (except those already inducted into the armed forces), and later to those men from 18 to 20 and from 45 through 64 who are still to be registered. Eventually the Government will have information on the

occupational skills of the entire male population between 18 and 64 years of age—approximately 40 million men.

The United States Employment Service will provide the Selective Service System with current information on the need for workers for war production so that these needs may be taken into account in classifying registrants for deferment or induction into military service. In any individual case the Employment Service will be able to provide factual information as to whether or not the individual possesses a skill urgently needed by the war industries.

Manganese Production Program Announced

A program of manganese production from low-grade domestic ores involving seven small projects and three large ones has been announced by William L. Batt, director of materials, War Production Board. The importance of manganese is readily apparent from the fact that an average of 14 pounds is required for the production of a long ton of steel.

The new plants, plus those already in operation, are expected to produce well over 600,000 tons a year in high-grade manganese concentrates, as compared with 30,000 tons domestically produced in 1939 and 40,000 tons in 1940. The United States never has been more than a negligible producer of manganese because deposits in this country are low-grade and present difficult engineering and technical problems in their recovery. This had made domestic manganese far more costly than that obtained from high-grade deposits in Africa, India, and Russia, from which the bulk of United States supplies have come.

The impetus of war and the threat of disruption of shipments from abroad, however, have brought a successful culmination to many years of research for methods to recover manganese from domestic deposits. Intensive studies and experiments carried on during the past year by the United States Bureau of Mines and Geological Survey and by private groups have developed methods that will produce high-grade manganese concentrates from 10- to 12-per cent ores. Results of the various tests have been evaluated by the advisory committee of the National Academy of Sciences and several have been recommended to the WPB for development. These will be applied on the three large projects that will produce more than two thirds of the expanded domestic output—in the Cuyuna Range of Minnesota, the Missouri River area in South Dakota, and in the vicinity of Boulder Dam in Nevada.

In addition to these three large projects, seven small ore-dressing plants are to be built in Arkansas, Montana, Utah, Nevada, Georgia, and Tennessee to treat production from small mines. These plants will treat from 150 to 500 tons per day of crude ore and will produce high-grade manganese concentrates and an appreciable amount of manganiferrous iron ore. Other manganese deposits are being examined and tested by the Bureau of Mines, Mr. Batt said, and domestic production can rapidly be stepped up to a million tons a year if it becomes necessary. Meantime, the United States has a sizeable manganese stockpile, which, with domestic production and imports from Cuba, will enable steel production to go forward without interruption until the new manganese mills are completed. Some of these will take only a few months and others more than a year, but all are expected to get into production in 1943.

Metals Drastically Curtailed for Consumers' Durable Goods

Orders already issued or about to be signed by the War Production Board provide for the virtual cessation of consumers' durable goods industries using critical metals in the United States and the conversion of their men, plants, and facilities to an all-out war effort, according to a recent statement by Donald M. Nelson, chairman.

Some production is still being carried on, but within three months almost all of it will be stopped except for that production necessary for war and essential civilian purposes. The elimination of less-essential production and the conversion program have already changed the face of American industry and are now harnesssing the entire economy to war.

Automobiles, washing machines, refrigerators, radios, lawn mowers, oil burners, and metal furniture are only a few of the many items which can no longer be produced with critical metals after cut-off dates provided in the various orders.

Two new orders with sweeping effect are in their final stages. One is a construction order which will confine all new construction to relatively small projects and defense work. The other is a new steel limitation order which prohibits the use of iron and steel in hundreds of items.

These orders, according to Mr. Nelson's statement, "mark the suspension of the consumers' durable goods metal industry and the civilian construction industry. They make possible the complete conversion of the men, materials and machine tools formerly devoted to these pursuits to war production.

"The steel order will prohibit at an early date the use of iron and steel in hundreds of specifically listed metal products. It also prohibits the use of specifically listed materials as a substitute. This list of materials includes all of the metals and the scarce plastics."

Summer Work in War Industries for NYU Student Engineers

Following consultation with government and industrial officials, the faculty of the College of Engineering at New York University, New York, N. Y. has adopted a new accelerated war training program, believed to be the first of its kind in the United States. The plan, as recently announced, will free third-year engineering students, who have completed all basic engineering studies, about May 15 to work with war industries for four months during the all-out production drive of this spring and summer. The academic program of all undergraduates will be accelerated by the elimination of most regularly scheduled holidays during the academic year. Some 250 seniors completed their studies in April 1942.

The program will make college classrooms and laboratories available during the summer for defense research and for the continuance and expansion of the training programs now being conducted for the Army Air Corps, Ordnance Department, Signal Corps, Weather Bureau, Navy, United States Office of Education, and other government agencies.

Preliminary surveys among personnel directors of aeronautical firms in the East indicate that the 80 junior aeronautical engineers enrolled in college would probably all be placed on or before May 15, and reports from other sources indicate that there may be a larger demand for junior electrical engineers for the four-month period than the college will be able to meet, the announcement stated. The demand for student engineers in other fields is also heavy.

Marine Corps Needs Electrical Engineers

The United States Marine Corps needs a large number of officers with electrical background for duty in the supervision and maintenance of radio aircraft warning devices, allied radio equipment and installations. A call to civilians between 20 and 40 years of age to apply for commissions in the Corps has been issued by the Commandant Lieutenant General Thomas Holcomb.

Candidates for commissions should be able to fill one of the following:

Hold a degree of bachelor of science of electrical, radio, or communication engineering or electronic physics awarded by an accredited college, or,

Hold a degree of bachelor of science in any engineering subject and have had reasonable practical experience in radio or electrical work, or,

Have successfully completed at least two years of electrical, radio, or communication engineering subjects at a college, university or commercial school of recognized standing and have considerable experience in one of those fields, or,

Have the equivalent of any of the above by reason of extensive practical experience in the field of radio where the applicant has been connected with the design, erection, or maintenance of ultrahigh-frequency radio transmitting or reception.

Men who are commissioned will be sent to an officers' school for three months for an indoctrination course in military training.

Anyone interested in applying for a commission in this specialized field should write to The Commandant, United States Marine Corps, Headquarters, Washington, D. C., stating qualifications and giving age, full name, and complete address. Applicants

living in Arizona, California, Colorado, Idaho, Nevada, New Mexico, Montana, Oregon, Utah, Washington, and Wyoming may write to Lieutenant-Colonel Raymond W. Conroy, Naval Reserve Aviation Base, Oakland Airport, Oakland, Calif.

While applicants must meet other standard qualifications of the Marine Corps, certain waivers in physical condition may be requested for men who are particularly qualified for this work.

Few Engineers in Congress

The accompanying tabulation of an analysis of the present United States Congress, made on the basis of occupation, reveals the small number of engineers included. The columns headed "Principal" indicate the chief classification; those headed "Former" a previous, secondary, or incidental classification.

Classification of Senators and Representatives by Occupation

	Senators		Representatives	
	Principal	Former	Principal	Former
Lawyers	57	6	253	12
Miscellaneous business	9	3	41	13
Farmers	7	6	27	15
Editors, publishers, etc.	9	2	25	11
Insurance, Real Estate	2		25	4
Professors, teachers	3	2	14	34
Public office	4	7	12	18
Doctors, dentists, etc	2		12	
Investments, banking	1	4	9	13
Not classified	1		9	
Engineers		2	5	4
Vacancies	1		3	
Total	96		435	

Compiled from Congressional Directory 1942 and "Who's Who in America."

Steel Specifications Changed

Changes in steel specifications designed to conserve the supplies of steel alloys were announced recently by the War Production Board. With the rapid increase in war production, it quickly became evident that unless steel alloys were conserved, there would not be enough for both the war program and essential civilian demands.

In anticipation of this shortage, representatives of the steel industry, the Society of Automotive Engineers, the Iron and Steel Institute, and other technical bodies were called together by the War Production Board to discuss national emergency steel specifications. The conservation of alloying elements in these specifications is based upon the principle that small quantities of several different alloys are more effective than large quantities of any single element.

It appears that these national emergency steels and certain others containing less strategic elements, or none, will soon be the only steels available. It is therefore imperative, the announcement explained, that industry take the necessary steps to change over as quickly as possible so as to be prepared when the supply of habitually used steels is cut off.

Steels containing the strategic elements nickel, chromium, tungsten, cobalt, and vanadium may be used only on extremely important functional parts. Hence, industry is urged to use carbon and intermediate manganese steels (1000–1100–1200 series), carbon-molybdenum (4000 series), manganese–molybdenum (8000–8100–8200–8300–8400–8500 series) or silico-manganese (9200 series) wherever possible.

Civilian Copper Use Cut Further

Rapid acceleration of the nation's arms production has resulted in a shortage of copper that will result in additional drastic curtailments of the amount assigned to civilian uses, according to a recent announcement by William L. Batt, chairman, Requirements Committee, War Production Board.

The Committee has adopted an over-all program allocating the available supply of copper for the current quarter of 1942, which calls for a drastic reduction in copper consumption by civilian users.

Direct military and shipbuilding requirements and the vital needs of the United Nations for the quarter will require practically all the copper available, in spite of the fact supplies of the metal have reached an all-time record.

At the same time, some copper is necessary for the maintenance of vital civilian operations, even at the expense of military production. Included in these civilian needs are copper for power lines, for new war plants, for machine tools, railroads, and the like. The result is that civilian consumption, even in important operations, will have to be curtailed. The program contemplates a cut of approximately 60 per cent in civilian use of copper from that of 1940, with a large proportion of the remaining 40 per cent devoted to "behind the lines" uses that support the military establishment.

High Steam Pressure on New Ship

The use of steam pressure of 1,200 pounds per square inch on the Steamship Examiner, with reheat at approximately 250 pounds, represents a noteworthy attempt of the United States Maritime Commission to bring American marine practice abreast of American power-plant practice on land. Built for the Maritime Commission by the Bethlehem Steel Company's shipbuilding division at their Fore River Yards, the ship is a full scale experiment in the use of high pressure steam with reheat for marine turbines.

Present marine practice limits boiler pressure to approximately 600 pounds per square inch, while 1,200 to 1,400 pounds is becoming common in land power plants. The new vessel now is undergoing sea trials, and it has been predicted that the results may affect the design of marine propulsion units for years to come.

Tin Smelter Being Rushed. The United States tin smelter now under construction in Texas will be rushed to completion with the assistance of an A-1-a priority rating for materials, J. S. Knowlson, director of industry operations, War Production Board, announced recently. The plant, which was started as an 18,000-ton smelter, has been increased to 52,000 tons capacity and may be increased further. It will process Bolivian tin ore, as well as concentrates from Malaya and the Netherlands Indies received since the outbreak of hostilities in the Pacific. While Bolivian ore is not expected in sufficient volume to keep the smelter in full operation over a long period, it has a large supply of ore on hand and any further reshuffling of military forces around the world may result in concentrates from other areas reaching the United States.

More Women Workers for War Production. Calling attention to the fact that employment of women in war industries is becoming increasingly necessary, the Training-in-Industry Bureau of the Labor Division of the War Production Board has issued a bulletin entitled "Increasing War Production Through Employment of Women." The bulletin suggests methods for fitting women workers into the war labor force as rapidly and efficiently as possible, and outlines steps necessary in their training for war jobs. It is based upon experience of American industries employing a considerable number of women, and on British experience in using women workers for war production.

INDUSTRY • • • • •

Electrical Testing Laboratories Bought by Employees

The plant and equipment of Electrical Testing Laboratories, New York, N. Y., which went into voluntary dissolution as of January 27, 1942, have been purchased by the former employees of the company. A new corporation, completely employee-owned, has been formed with the corporate title of Electrical Testing Laboratories, Inc., and will carry on the same type of technical activities formerly engaged in by ETL, with such additional work as may be brought about by the war production program. Officers of the new organization are: Preston S. Millar (M'13), president; F. Malcolm Farmer (F'13), vice-president and chief engineer; D. J. Lees, vice-president and treasurer; Gordon Thompson (M'18), assistant treasurer; Caroline E. Slocum, secretary. Members of the board of directors, in addition to Messrs. Millar, Farmer, and Lees, are William F. Little,

George Diggles, Leonard J. Lewinson (M'38), and Norman D. Macdonald.

Increased Services in Emergency Reported by AT&T

Development of air-defense communications systems, increased radiotelephone service overseas, and great expansion of transcontinental telephone facilities are among advances described by the American Telephone and Telegraph Company in its annual report for 1941, recently issued.

Extensive communications systems require in defense against enemy air attack, developed in co-operation with the United States Army, were installed during 1941. Taking full advantage of existing telephone networks, means are provided by which the Army can receive and correlate information of the movement of enemy aircraft from civilian observers, direct defense action of military forces, and warn civilian defense authorities, who also can direct necessary civilian activities.

Bell System long-distance facilities were increased by over a million miles of circuits during 1941, the report states. The wide use of broad-band carrier systems has made possible rapid extension of such facilities without excessive draft upon supplies of copper and other scarce materials. Transcontinental facilities have been increased by the addition of 60 circuits, with about 36 more in preparation. The first transcontinental underground cable, completion of which is expected to double present transcontinental facilities, has been completed as far as Denver, Colo., and is expected to reach the Pacific Coast by the end of 1942, according to the report. About 4,000 miles of toll and long-distance telephone cable were added to the Bell System in 1941, most of it by the recently perfected method of plowing the cables into the ground. First commercial use of the recently developed coaxial cable was made on the 200-mile cable between Minneapolis, Minn., and Stevens Point, Wis. (*EE, Feb. '41, p. 71*).

First installation of a newly developed 12-channel radiotelephone system was placed in service across Chesapeake Bay where a direct radio route of 30 miles reaches the same destination as more than 400 miles of land-wire circuits. Radiotelephone facilities are being improved and augmented, with additional circuits provided to Panama, the Philippines, and the Netherlands Indies, in 1941; two additional circuits to Honolulu, T. H., and one additional circuit each to San Juan, Puerto Rico, and Rio de Janeiro, Brazil, are planned for 1942, the report states.

Record Highs in U. S. Production of Power Reported by FPC

Power production for public use, including that produced by railways, railroads, and non-central-station plants, in the United States reached an all-time high mark in 1941, the Federal Power Commission reported recently in presenting its preliminary estimate of 167,955,000,000 kilowatt-hours. This far exceeds the highest annual total heretofore recorded and is approximately 16 per cent more than was produced during 1940 which had exceeded any previous year. The 1941 production when compared with 1939 shows an increase of nearly 29 per cent. Of the total energy reported, 3,009,000,000 kilowatt-hours were produced by electric railroads, electric railways, and other miscellaneous plants.

The production of electric energy by use of water power amounted to 51,149,000,000 kilowatt-hours, or approximately 7 per cent more than was produced by this means in 1940. This represents 30 per cent of the total output for the year. The average for the 22 year period from 1920 to 1941 is 36 per cent of the total.

The total installed capacity of generating plants as of December 31, 1941, was 44,024,000 kw. This represents a net increase of approximately 2,385,000 kw during 1941. Capacity at the end of 1941 was 5.7 per cent more than the total reported for December 31, 1940.

Coal consumption increased approximately 11,400,000 tons or about 21 per cent over the amount consumed during 1940. Oil consumption also increased 21 per cent, or about 3,500,000 barrels, over that used during the previous year. The amount of gas consumed increased nearly 21,000,000,000 cubic feet, which represents a gain of 11 per cent when compared with 1940.

The accompanying tables show for the United States and for its geographic divi-

Table I. Annual Production of Electric Energy in the United States, 1941 and 1940

Geographic Division	Millions of Kilowatt-Hours								
	Total			By Use of Water Power			By Use of Fuel		
	1941	1940	1941/1940 (Per Cent)	1941	1940	1941/1940 (Per Cent)	1941	1940	1941/1940 (Per Cent)
United States	167,955	144,985	+16	51,149	47,753	+ 7	116,806	97,232	+20
New England	10,437	8,968	+16	2,551	2,773	− 8	7,886	6,195	+27
Middle Atlantic	41,317	36,383	+14	7,286	7,721	− 6	34,031	28,662	+19
East North Central	39,381	33,612	+17	3,092	2,858	+ 8	36,289	30,754	+18
West North Central	9,910	8,481	+17	2,671	1,693	+ 58	7,239	6,788	+ 7
South Atlantic	20,944	17,618	+19	4,807	5,753	− 16	16,137	11,865	+36
East South Central	10,074	8,472	+19	6,170	6,058	+ 2	3,904	2,414	+62
West South Central	8,834	7,434	+19	778	319	+144	8,056	7,115	+13
Mountain	9,189	8,544	+ 8	7,659	6,770	+ 13	1,530	1,774	−14
Pacific	17,869	15,473	+15	16,135	13,808	+ 17	1,734	1,665	+14

Table II. Annual Consumption of Fuels in Generating Electric Energy, 1941 and 1940

Geographic Division	Coal (Thousands of Short Tons)			Oil (Thousands of Barrels)			Gas (Millions of Cubic Feet)		
	1941	1940	1941/1940 (Per Cent)	1941	1940	1941/1940 (Per Cent)	1941	1940	1941/1940 (Per Cent)
United States	64,795	53,398	+21	20,259	16,772	+ 21	203,992	183,157	+11
New England	3,523	2,915	+21	6,707	4,299	+ 56			
Middle Atlantic	20,344	16,781	+21	3,528	4,000	− 12	38	461	−92
East North Central	23,650	20,015	+18	476	425	+ 12	9,602	12,911	−26
West North Central	3,945	3,620	+ 9	1,360	1,399	− 3	45,564	43,152	+ 6
South Atlantic	8,778	6,462	+36	4,854	4,015	+ 21	5,716	4,817	+19
East South Central	3,119	1,895	+65	320	161	+ 99	10,784	6,392	+69
West South Central	516	799	−35	803	748	+ 7	111,670	91,651	+22
Mountain	917	911	+ 1	491	940	− 48	8,785	9,806	−10
Pacific	3			1,720	785	+119	11,833	13,967	−15

sions the annual production of electric energy by use of water power and by the use of fuels for the years 1941 and 1940, and the percentage change of 1941 over 1940 in the production of electric energy and the use of different fuels for such purpose.

The information in the accompanying tables is preliminary and is based on the figures of production of electric energy previously published in the monthly reports issued for 1941. The output of central stations, both publicly and privately owned, electric railway plants, plants operated by electrified railroads generating electric energy for traction, Bureau of Reclamation plants, and that part of the output of industrial plants which is sold are included in these data. Accurate data are received each month representing approximately 98 per cent of the output shown; the remaining 2 per cent of the output is estimated, so that the data represent 100 per cent of the generation.

Resins, Rubbers, Plastics Abstracts

An abstract service designed to cover the field of synthetic resins, rubbers, and plastics from scientific and technical periodicals has been announced by Interscience Publishers, New York, N. Y. The abstracts, edited by H. Mark, of the Polytechnic Institute of Brooklyn (N. Y.) and E. S. Proskauer, will be published in 12 issues, the first of which contains 33 pages. The condensations are intended to be comprehensive in that they are planned to contain most of the data and charts of the source materials. They will be issued in looseleaf form, numbered to facilitate filing, and are obtainable at $35 per year (binder $3).

CAA Orders Blind Landing Systems. Equipment for instrument-landing systems for installation at ten principal airports in the United States has been ordered by the Civil Aeronautics Administration. This is in addition to installations of systems being made during 1942 at La Guardia Field, New York, N. Y., and the municipal airports at Atlanta, Ga., Chicago, Ill., Cleveland, Ohio, Kansas City, Mo., and Los Angeles, Calif. The instrument-landing systems, which are being manufactured by Federal Telegraph Company, associate of International Telephone and Telegraph Company, permits pilots to land "blind," entirely by instrument, if weather conditions prevent normal landing. The equipment has been tested for several years at the CAA Experimental Station, Municipal Airport, Indianapolis, Ind. (*EE, Dec. '40, p. 495–502*).

Electric Rates Reported by FPC. The report by the Federal Power Commission showing rates, in the form of typical monthly bills, for residential electric service, commercial light, commercial power, and industrial service in cities in the United States with populations of 50,000 or more, has been issued for rates as of January 1, 1942. Copies of the report may be obtained at ten cents each from the Commission, Washington, D. C.

New Process in Fluorescent Manufacture. A new manufacturing process, said to increase life and brilliance of fluorescent lamps, has been developed by the Hygrade Sylvania Corporation, and is in operation at its plant at Danvers, Mass. The process, which makes possible more accurate regulation of the amount of mercury inside a fluorescent lamp tube, is based on the explosion of a mercury-filled nickel tube inside the lamp during manufacture. Previously mercury was deposited in the lamp tube just before sealing, by a mechanical device operating on the principle of an eye-dropper.

EDUCATION . . .

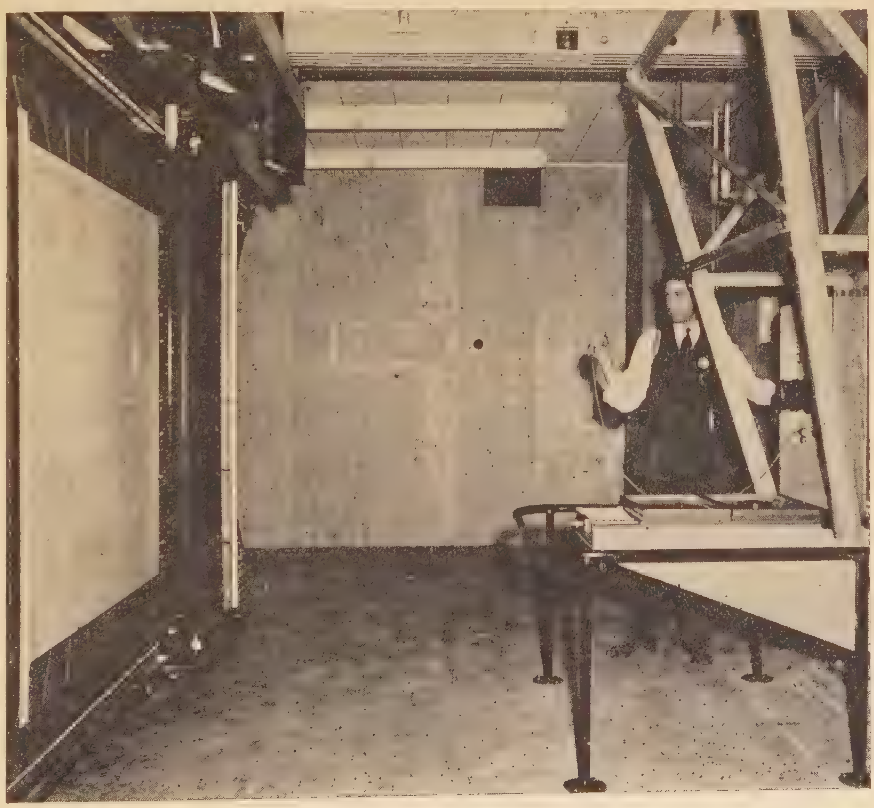
Iowa Continues Management Course. The three-week summer course in management, offered annually since 1939, is again being presented at the University of Iowa, June 8–26, 1942. The course, concerned chiefly with production planning, plant layout, motion and time study, and related subjects, is designed for engineers, executives, and others interested in such problems. Especial attention is being given this year to procedures for conducting factory training programs. Ralph M. Barnes, professor of industrial engineering, is again in charge of the course.

Coffin Fellowships Announced. Fellowships have been awarded by the Charles A. Coffin Foundation to five outstanding graduates of five different colleges and uni-

Second "Photodraftsman" in Use by Aircraft Company

Consisting primarily of a huge camera occupying two rooms, a second "photodraftsman" has been placed in operation at the Baltimore, Md., plant of The Glenn L. Martin Company, manufacturers of Martin bombing planes. An earlier unit has been in use for about 2 1/2 years, and several other units have been constructed for other aircraft and automotive companies. Several improvements have been made in the new camera, designed to make operation faster and more efficient.

The huge camera can reproduce in a few minutes drawings up to five by ten feet directly on nearly any kind of surface—metal, wood, cloth, linen paper, or glass, to mention a few—by simply coating the surface with a special photographic emulsion. When such a sheet is placed in huge developing tanks, the original drawing appears in exact scale, fractional scale, or multiple scale, as desired. To produce equivalent drawings by hand might require several days. Thus the device is a great time and labor saver and therefore is a heavy contributor to increased production in a vital wartime industry. The company has estimated that the original unit "in effect presented the company with 307 able men."



versities, enabling them to continue or undertake research in the fields of electricity, physics, and physical chemistry in educational institutions here or abroad. The Foundation, established by the General Electric Company, Schenectady, N. Y., in honor of its first president, makes an annual grant of fellowships. D. C. Prince (F'26) AIEE president and vice-president of the General Electric Company, is a member of the fellowship committee. This year's recipients are:

B. D. Abramis, University of California, to continue at that school the theoretical and experimental study of hyper-frequency wave guides.

R. W. Hull, Yale University, to study at Massachusetts Institute of Technology the chemical nature of thermionic emitters.

E. R. Kane, Union College, to conduct an experimental study of the absolute temperature scale at Massachusetts Institute of Technology.

Hershel Markovitz, University of Pittsburgh, to work out the theory of the use of the distribution functions in calculating the thermodynamic properties of liquids at Columbia University.

A. E. Snowden (Enrolled Student) Carnegie Institute of Technology, to carry on there a study of the design of variable, smooth model transmission lines.

OTHER SOCIETIES

New Society Becomes Associate of American Institute of Physics

The American Society for X-Ray and Electron Diffraction, which was organized in July 1941, recently was made an Associated Society of the American Institute of Physics. The latter organization was formed in 1931 by four societies active in various fields of physics and was shortly afterward joined by a fifth society. Its present member societies are the American Physical Society, Optical Society of America, Acoustical Society of America, Society of Rheology, and American Association of Physics Teachers. Its bylaws provide also for the relationship as associated societies of new organizations concerned with physics and related fields. The American Society for X-Ray and Electron Diffraction now has about 200 members. Its present officers are: Doctor B. E. Warren, president; Doctor M. J. Buerger, vice-president; Doctor George Tunell, secretary-treasurer.

Future Meetings of Other Societies

American Institute of Chemical Engineers. 34th semiannual meeting, May 11–13, 1942, Boston, Mass.

American Physical Society. 249th meeting, June 25–27, 1942, State College, Pa.

American Society for Testing Materials. 45th annual meeting, June 22–26, 1942, Cleveland, Ohio.

American Society of Heating and Ventilating Engineers. Semiannual meeting, June 15–17, 1942, St. Paul, Minn.

American Society of Mechanical Engineers. Semiannual meeting, June 8–10, 1942, Cleveland, Ohio.

Canadian Electrical Association. Annual meeting, June 25–26 (tentative), Murray Bay, Que.

Institute of Radio Engineers. Summer convention, June 29–July 1, 1942, Cleveland, Ohio.

National Electrical Manufacturers Association. May 10–15, 1942, Hot Springs, Va.

National Fire Protection Association. May 11–15, 1942, Atlantic City, N. J.

Pacific Coast Electrical Association. Annual convention, May 21–22, San Francisco, Calif.

Society of Automotive Engineers. Semiannual meeting, May 31–June 5, 1942, White Sulphur Springs, W. Va.

Society for Promotion of Engineering Education. Annual meeting, June 27–29, 1942, New York, N. Y.

ASTM Publishes Card Index

Intended for use in the Hanawalt method of chemical analysis by X-ray diffraction, the 4,000-card index includes Hanawalt's original published data, his later corrections, as well as material contributed by the Aluminum Company of America and the New Jersey Zinc Company and data taken from technical literature in the English language. The cards aim to give all pertinent data found in the sources with provision for insertion of accessory data. The index identifies the three strongest lines in the X-ray diffraction pattern of about 1,300 crystalline compounds. It is packed in finished container boxes and may be obtained from the headquarters of the American Society for Testing Materials, 260 South Broad Street, Philadelphia, Pa., at $50 per set.

JOINT ACTIVITIES

American Standards for 1942. "American Defense Emergency Standards" are given a special section in the list of nearly 500 American Standards for 1942, publication of which was recently announced by the American Standards Association. All American Safety Standards also are listed together in a separate section. Definitions of technical terms, specifications for metals and other materials, methods of test for the finished product, dimensions, safety provisions for the use of machinery, and methods of work are included among these Standards, which reach into every important engineering field and serve as a basis for many municipal, state, and Federal regulations. Copies of the 1942 list may be obtained without charge from the ASA, 29 West 39th Street, New York, N. Y.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Postwar Planning

To the Editor:

In recent issues of *Electrical Engineering*, references have been made to some of the problems that will have to be dealt with after the war.* The results of some preliminary investigations made in Great Britain may be of help to American engineers in the consideration of their own problems.

Sufficient value is assigned to this subject in England for a full-time member of the main cabinet of the Government to be detailed to postwar planning. In addition, there is a full departmental Ministry of Works and Buildings, which is largely concerned with actual planning. This latter is mainly related to town and country layouts, to structural arrangements, and so on, and not to the methods which should be used in running industry and the public services.

Many of the professional Institutions in Great Britain, such as those of the Civil, Mechanical, and Electrical Engineers, and including that of Industrial Administration, have set up postwar planning committees or groups. The most common constitution is for a main council to be set up, and under this a number of committees and subcommittees, as necessary, to deal with different aspects of the subject as it affects the particular profession concerned. The membership of these groups is in the main drawn from men who have by their attainments proved their ability to run the prewar system of industrial organization.

Many who are not actually engaged in postwar planning are nevertheless interested in the subject. This is especially so with the younger engineers, for they are very deeply concerned in the planning now being done by their elders and superiors. They can have a sound trust in the solutions that will be determined by the engineers who have been called to serve on the various committees. But younger engineers sometimes wonder what will be the future arrangement of industry. It is certain that the opportunities available to the younger engineers are going to be conditioned by the types of organizations set up in the

**Editor's Note:* Discussions of this general subject were featured recently by the AIEE at its South West District meeting, St. Louis, Mo., October 8–10, 1941; Southern District meeting, New Orleans, La., December 3–5, 1941; and winter convention, New York, N. Y., January 26–30, 1942; see *Electrical Engineering*, November 1941, pages 548–9; January 1942, pages 40–1; March 1942, pages 148–52.

future. In the execution of such a large project as postwar planning, the opinions of the younger engineers will be of value. It is they who, in a large degree, will be called upon to operate the schemes and establishments devised by those who are at present engaged on planning work.

In addition to the specific problems within an industry, there are others common to all industries. These latter can be divided into two categories: those of a permanent nature, and those covering a transition period.

PROBLEMS OF TRANSITION PERIOD

The political, social, and economic structure of the country under consideration, and those of other countries, will have considerable effect upon both the transition period and upon the final plan.

The wartime developments and factors from which transition problems would appear to emanate in Great Britain are as follows.

1. Concentration of production
2. Cessation of manufactures
3. Effect of war damage
4. Decrease in maintenance
5. Control of factory localization
6. Evacuation of offices
7. Development in personnel management
8. Re-instatement of operatives
9. Loss of young men
10. Changes in distribution
11. Simplification of operations
12. Clerical field

Some of these problems will no doubt face members in America too, and others may occur in a modified form. A few comments upon each subject may be of interest and help.

Concentration of Production. The shortage of many raw materials and the policy of restricting consumption has meant a shrinkage in the work available to many firms in a number of industries. To bring about more economical operation, the remaining production has been concentrated in a few highly efficient, modernly equipped factories. Redundant staff either has been transferred to the Forces, or to munition making. This latter may be at other factories, or it may be at a company's own plant, where new machines have been installed or the old ones converted.

Cessation of Manufactures. In some industries, it has not been possible to convert redundant plant into munition-making machinery, while in other industries, all manufacture has been prohibited. After the war, decisions will have to be made about the restarting of many of these concerns, the development of their markets, the obtaining of the necessary skilled labor, and so on. Moreover, now that some factories have had their reduced output concentrated in a few efficient plants, these latter enjoy a special advantage in publicity.

Effect of War Damage. Problems will arise not only from the restarting in peacetime of factories which have been destroyed during the war, but also about those factories which have been able to install better equipment in place of that damaged by enemy action.

Decrease of Maintenance. The great drive for increased production, with "all out" running of plant, consequent reduction in idle time, and the restriction in skilled staff available, has naturally resulted in greater "wear and tear" of plant, and curtailment of maintenance. This will have repercussions not only on the mechanical equipment, but on the financial side too. Probably a further problem will arise in the desire of managements to renew their plant with the most efficient equipment at the cessation of hostilities. Actual development in improvements of plant for many consumption goods, however, may be very much retarded by the War.

Control of Factory Localization. Consequent upon the clearance of large areas by enemy action, problems will no doubt arise in the reconciling of factory localization and town planning. This problem has many other ramifications, especially in its relation to town size, distribution of population, and so on. Even before the War it was sufficiently important to warrant the setting up by Parliament of a Royal Commission. The report which the Commission has issued will provide for England a sound basis upon which future planning can be made.

Evacuation of Offices. A vast number of administrative offices of English factories were evacuated at the beginning of serious bombing. It has been found that many administrative functions do not need close proximity to the actual factory, and hence could remain evacuated. In peacetime however, the advantages of having the head office in a locality where it is in close touch with those of its customers, its competitors, and its complementary producers, will probably reassert themselves.

Development in Personnel Management. This subject did not, before the War, receive the attention it should have done. The increased production drive, the dilution of labor, and other factors, have made many firms realize the advantages of employing a personnel manager. The Ministry of Labor has been very active, too, in bringing about an expansion of the appreciation on this subject, and there would seem to be little doubt that this increased consideration should be retained after the War.

Reinstatement of Operatives. Under the National Service (Armed Forces) Act, it is obligatory upon employers to reinstate in their old jobs those men who have been conscripted during the war. This subject is bound up with the Government's policy of demobilization, and affected by a number of the other problems mentioned herein.

Loss of Young Men. The loss will be from at least two groups: men who are killed or incurably wounded, and men who wish to make the Services their life career, rather than return to industry. The loss is likely to be most seriously felt in managerial and executive positions, and it may be that after the War, some of the age-limit restrictions will have to be relaxed.

Changes in Distribution. A very large change in the distribution of population has been brought about by evacuation. After the war, there will no doubt be a large movement back to the towns, as is well evidenced when any long-time lull occurs in air-raiding. It is probable, however, that a considerable percentage of the people concerned in this redistribution will remain in the country after the war, especially those who have moved only a few miles out of a town.

Simplification of Operations. Problems can easily be foreseen, consequent upon the simplification of actual manufacturing operations brought about in the war, because of either a reduction in man power or a decrease in the average skill of operators.

Clerical Field. Reduction in clerical work brought about by the shortage of staff and the need to simplify records is going to be a matter for examination. The discontinuity in records is a subject of serious concern to many people responsible for the direction of industrial establishments.

METHODS OF STUDY

The administrative and executive problems mentioned naturally need breaking down into functional sections. It has been suggested in England that the sections and their order should be as follows:

(*a*) Marketing
(*b*) Production planning
(*c*) Personnel
(*d*) Methods and control of production
(*e*) Methods of distribution
(*f*) Clerical control
(*g*) General management

Apart from the major study of the coordination of the functional sections, there would seem to be two specific problems that call for special study under the heading of General Management. These can be expressed as follows:

1. The training of general managers on the basis of inculcating a sincere acceptance of the belief that effective management comes from the application of basic principles and is the key to industrial progress.

2. The making good of deficiencies in the supply of executive staff because of military service and other wartime factors.

Table I is an attempt to integrate the probable sources of transition period problems, with the functional sections of industry likely to be affected.

Probably the development in personnel management and the reinstatement of operatives could well be studied under all functional headings. It is obviously desirable that groups studying these problems should not proceed as if each were in a watertight compartment. Throughout the whole process of evolving a satisfactory solution it will be essential to have intercommunication between sections.

INTERNAL-ORGANIZATION PROBLEMS

Some of the problems mentioned in England as meriting urgent attention and study are named in the following list. It is not exhaustive and some of the problems will probably overlap; moreover, they are

not given in order. Postwar planning will be successful only to the extent that it can solve these matters, so that we shall continue to obtain the advantages of group activity without losing those of individualism.

1. The relation of the functions of planning and administration.

2. The relation of control to competition.

3. How collective control and decentralized responsibility can be made compatible.

4. What should be the relation of expert and administration officials? This involves a consideration of what the advisory function really is.

5. The process of the correlation of policies. This work should certainly begin in the early stages.

6. The process of co-operative research.

7. How to classify experience. It would seem that we have hardly begun to tackle this important problem.

These problems, and those adumbrated previously, are mainly concerned with the general principles applicable to all industry. They are, in fact, problems of our way of life in some degree and will have a bearing upon a country's general social structure.

Postwar planning as previously described is being studied by the Institute of Industrial Administration. The Institution of Electrical Engineers is dealing with questions more closely related to the electrical industry. The latter Institution has set up a main Committee to deal with postwar planning as it affects the subjects of most interest to its members. Subcommittees have been constituted as follows:

1. Education, training, and personnel.

2. Fundamental and applied research.

3. Electricity supply, distribution and installation.

4. Production, manufacture, and employment.

5. Telecommunications, reconstruction and development.

6. Standardization of material and design.

7. The general policy of the Institution toward problems of postwar reconstruction and development, including any desirable changes in the structure and machinery of the Institution.

Table I

Functional Section	Transition Period Problem
Marketing	Concentration of production
	Cessation of manufactures
	Control of factory localization
	Changes in distribution
Production planning	Concentration of production
	Cessation of manufactures
	Effect of war damage
	Decrease in maintenance
	Control of factory localization
	Simplification of operations
Personnel	Control of factory localization
	Evacuation of offices
	Development in personnel management
	Reinstatement of operatives
	Loss of young men
	Simplification of operations
	Clerical field
Methods and control of production	Effect of war damage
	Decrease in maintenance
	Simplification in operations
Methods of distribution	Changes in distribution
Clerical control	Evacuation of offices
	Clerical field

The Subcommittee on electricity supply has already set up a number of further committees to deal with specialized problems within its terms of reference. It is the Institution's policy, as part of the central idea of getting the best thought on these subjects, to issue papers for the general membership to discuss. The first example of this is a paper entitled "A Critical Review of Education and Training for Engineers" by Doctor A. P. M. Fleming (F'34) C.B.E., M.Sc., who is Local Honorary Secretary for the AIEE in Great Britain.

PROBLEMS OF REORGANIZATION

The vitality of modern industry, like that of an organism, is measured by its power of response to external stimulants and self-adaptation to modified environment. Mobility, in this sense of the term, does not imply incessant or purposeless movement or change, and may be consistent with a high degree of stability and complexity of structure. It does imply, however, the power of spontaneous modification and rearrangement to meet changes in economic conditions, and of internal modification to meet such changes. This is true both of the material and the human factors, of methods of administration, and of relations among classes, as well as of the personal skill, enterprise, and leadership which individuals bring into the common stock. It is, therefore, a matter of supreme necessity in this period of rapid and insistent flux and transformation to maintain unimpaired the qualities of initiative and flexibility of temperament, the power of readjustment and adaptation, and the capacity for free and willing co-operation among all partners in production and distribution. Any waning of these powers could only mean an increasing rigidity and stultification of economic structure and a progressive enfeeblement of its vitality, for which no measures of external support or defensive organization could compensate.

In the early days of new combines or amalgamations, the emphasis on the human equation becomes very apparent. This emphasis is not without reason, for the chief difficulties of efficiencies in combinations of undertakings are the personal relations of the new officers. Much can be smoothed out by deliberate design and planning of the organization's structure before it commences to operate, particularly in the careful definition and allocation of authorities and functions in the new unit.

The theoretical economies and advantages of large-scale layout may be realized if, and only if, they are not taken for granted. One of the weakest points in present-day large-scale organizations is the failure to find the best way of applying the energies of those who work in industry most effectively for the industry and for themselves. One of the principal causes of this failure is excessive preoccupation with financial matters at the expense of human relationships.

The structure of an organization that is best for a concern today will not be the best in all its details a month from today if the concern has grown, as any live undertaking would wish to do. Reorganization therefore has to be carried along all the time, a continuous evolution, not neglected until collapse can be averted only by revolution. Each evolutionary change must be expected to seem revolutionary with respect to some unit of the whole. Evolution is in a sense decentralized revolution. To maintain too slow a rate of change in structure invites a real revolution, whatever name it may go by.

Continuous reorganization can no more be left to chance than can routine operations. Some kind of special provision for it must be made, or it will lag behind the needs of the undertaking and economic conditions. Mental security is so important for an organization of men and women that without preparation, patience, and skill in cultivating change progress can only be made, as it has chiefly been made in the past, by cessation and the formation of a new body.

Moreover, it is important for an organization to hold itself open to the advantages of getting and assimilating unusual men. If it chooses to operate under a strict promotion policy, it should provide more than usual opportunities for its own men to get their educations broadened and their imaginations fertilized by outside contacts.

NATIONAL PLANNING PROBLEMS

There are obviously certain matters that need attention and decision with regard to any national planning boards or committees that may be set up to control and direct individual industries. Such boards or committees are certainly likely to be in existence during any transition period and it may be that they will continue into normal times.

The terms of reference of committees set up by various industries have already been delimited. These deal with particular technical and personnel problems likely to arise in the future. Mention was also made of general principles that are applicable to all industries, but the conclusions reached by different committees may also be different. A stage will inevitably be reached when the committees will have to think out methods whereby their conclusions can be put into operation in the industry with which they are concerned. Moreover, the necessity for liaison contacts will also become apparent, and hence the following problems are apposite for consideration.

1. What changes, if any, will have to be made in the organization of separate undertakings of an industry if there should be, first, some union or consolidation of enterprises, and second, some union, amalgamation, or composite control of various industries?

2. How to ensure that planning does not mean uniformity nor too great a centralization.

3. How the flexibility of the organization for national planning can be attained and maintained, so that experiments in all industries shall be encouraged and the results made known for the enlightenment of all.

4. How can the expert principle and the representative principle be combined in a national planning board?

5. The relation of central planning to the planning which must take place in all the separate units.

6. The delimitation of the scope of a planning board.

7. How to make intelligent opinion of a country contribute to our collective life, to economic planning, and to international agreements.

8. How to provide the flow both ways of information from industries or the public to the planning board, and understanding of the policies of the planning board back to the industries or the public.

9. How the policies of the planning board can secure the necessary legislation for its requirements.

In Great Britain there is a growing realization that industries should be governed by certain social principles. The main points are summarized as follows:

1. Industry is a human activity which exists to serve the community by producing and distributing the goods and services needed by the community.

2. In doing this, all industries should provide conditions of justice and well-being for all grades of workers, in which they are able to develop their individuality and their sense of belonging to community life.

3. All industries have the responsibility of guarding their members from insecurity, by co-operation (*a*) of member firms within an industry, (*b*) of one industry within another, and (*c*) of industries within the State.

4. All grades of workers should have some representation, and also have access to any information affecting the firm's conduct which may be of value in their work.

5. Industrial activity is a trust and implies the responsibility in the exercise of this trust, by the owners of capital, the directors of enterprises, the managers, and all grades of workers, in relation to the community.

It is the aim and ambition of the electrical industry in Great Britain to be a leader in its conditions of employment, its methods of dealing with consumers and purchasers, and in the general operation of its activities. In particular, there is a growing opinion that the electricity supply industry, which carries out a public service of a unique character, having unrivaled flexibility, with great economic power and special social potentialities, should be among the most advanced in its postwar organization. It is surely the function of a specially privileged industry to set the pace for the less privileged and less progressive. Any postwar reorganization of electricity supply, it is felt, will lack one of its potentially finest and most valuable elements if no attempt is made to bring the methods of handling personnel up to the highest known standard.

Put briefly, what is wanted, is that the conditions and methods which will enable men to give their best to the undertaking, shall be put into operation. Furthermore, it would appear that the point of view that industry exists for the benefit of the consumers rather than that of the producers should be paramount. Moreover, this applies not only to the products themselves, but to the methods of production.

G. V. HARRAP (A'34)

(Technical assistant and assistant distribution engineer, West Ham Corporation Electricity Department, London, England)

Books for Engineers

To the Editor:

I was particularly interested to read Clark J. Wells' letter in *Electrical Engineering* for September 1941 (page 465) under the heading "Books for Engineers." I agree entirely with Mr. Wells. I consider the omission of answers from American textbooks has always placed them at a serious disadvantage with books in which the answers are given. It is realized that many of the leading American textbooks are written by professors, primarily for use in their own teaching institutions, but these writers would do well to realize that their books are frequently so good that they have a far wider range of use than for the institution for which they were possibly originally intended.

I would strongly support Mr. Wells and may I express the hope that American writers may, in future, see their way to give the answer to every problem they include in their textbooks. A notable exception to this is the recently published "Advanced Mathematics for Engineers" by Reddick and Miller.

A. S. PLOWMAN (A'16)

(Lecturer-in-charge, electrical engineering department, Sydney Technical College, Sydney, N. S. W., Australia)

Equivalent Circuits for the Hunting of Electrical Machinery

To the Editor:

There is a famous story of the insect world:

The centipede was happy quite,
Until the toad for fun,
Said, "Pray which leg comes after which?"
Which raised his mind to such a pitch
He fell exhausted in the ditch,
Considering how to run!

Strange though it may appear, this story has a direct analogy with modern engineering developments. The centipede's legs were guided by his nervous system, but these controls had their wires crossed when his brain failed to guide them properly.

Just so, our modern electromechanical systems, whether supplying power for our homes, or rolling steel, or making paper, or operating the fans of a great wind tunnel, depend on delicate electric controls for their continued operation. These controls, of regulators, governors, dampers, relays, and amplifiers, must be accurately adjusted to assure fast operation, stability during disturbances, and ready response to the will of the operator.

No longer can we think of an electric system as a collection of motors, generators, and transformers tied together by wires. We have to think of the system as a living, dynamic being, whose utmost extremities will shiver at the least shock. The designers must consider the system as a whole, and make each part fit the others, as the Deacon did in designing his "wonderful one hoss shay." But the design of a nervous system is a much more difficult matter than designing either the wheels of the shay or a leg of the centipede!

It is interesting to see how this problem has been attacked by system engineers. The first thing they did was to devise distinct electric circuits to represent each separate element of the system. These separate "equivalent circuits," when subjected to voltage, or current, or surges, respond in just the same way as the actual machines do, only the results are calculated or read on meters. The next thing was to put all these circuits on a common basis, so they could be combined into one all-inclusive circuit for the system. In such a combined circuit, the energy in the live steam may be traced through the successive transformations into kinetic energy of motion, the shaft power supplied to the generator, the electric energy reaching the bus bars, the reactive energy stored in inductances, and the ultimate heat, or mechanical energy, used by the consumer.

Next, it was necessary to find a way to calculate the circuit performance without requiring an army of computers, or weeks of time. Here is where the a-c network analyzer came in—a marvelous assembly of ready made circuits, on which any particular circuit can be "plugged in" very quickly. By this means, meter readings give the performance of any system at any instant.

There was still something lacking, however, to answer the questions: How stable is the system? How much restoring torque is there after a disturbance? How quickly will an oscillation die out? This need too has been met, by a new generalized type of equivalent circuit, obtained by a "tensor transformation" of the circuits heretofore used. The transformed circuits can also be put on the a-c network analyzer, the desired values of damping and restoring torques can be read off the meters, and the stability of the system examined in detail.

These recent advances in system theory are more and more dependent on "tensor analysis," that generalized theory of circuits pioneered by Gabriel Kron over the past ten years. Kron's idea from the beginning has been to develop a completely general theory of electric machines, so that the theory of any particular type of machine can be simply derived, as a special case of the generalized machine. To do this, he developed tensor expressions for the properties of a machine with a large number of windings, slip rings, and a commutator; but no connections between windings nor with any external circuits. Then, for any particular machine, he represented the necessary winding connections by a "connection tensor," which, multiplied into the generalized tensor expression, gave the tensor expression for that machine. Tensors deal only with measurable quantities, and they may be used equally well to describe mechanical, thermal, or hydraulic as well as electric phenomena. Indeed, tensors were first developed by mathematical physicists to carry out their investigations of atomic structure and relativity theory, free from the restrictions of any particular geometry, and there are many fascinating analogies between their results and those of the new electric-system theory.

Kron's latest work, in developing circuits for calculating system stability, is described in a paper presented before the 1942 AIEE

winter convention, appearing on pages 290–6 of the *Transactions* section of this issue. A companion paper, "The Doubly Fed Machine," by Kron and two of his associates, S. B. Crary and C. Concordia, describing the application of the theory to the case of the motor drive of large wind-tunnel fans, appears on *Transactions* pages 286–9.

P. L. ALGER (F'30)

(Staff assistant to the vice-president in charge of engineering, General Electric Company, Schenectady, N. Y.)

NEW BOOKS • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

These and thousands of other technical books may be borrowed from the library by mail by AIEE members.

Plastics in Engineering. Second edition. By John Delmonte. Penton Publishing Company, Cleveland, Ohio. 601 pages, illustrated, 6 by 9 inches, cloth, $7.50.

Aims to indicate the advantages and limitations of various plastic materials and includes discussion of new materials and techniques. Organic plastics in cast, laminated, or molded form are discussed as competitive and supplementary material to existing designs employing wood, ferrous, or nonferrous alloys, and data on their physical, thermal, electrical, chemical, and optical properties are presented. In addition new information on plastic-bonded plywood, adhesives, extrusion, synthetic rubber, and rubber-like resins is given. The purposes for which various plastics are applicable, and the best methods of molding or fabricating are suggested. Characteristics of the different types of mold construction, and the composition and preparation of molding materials are also described.

ASTM Standards on Electrical Insulating Materials. Published by the American Society for Testing Materials, Philadelphia, Pa. 448 pages, illustrations, etc., paper, $2.25.

Latest edition of this ASTM annual publication containing 58 specifications and tests as of December 1941 is enlarged by the inclusion of new standards and several reports and papers. Subjects covered include the punching quality of laminated phenolic sheet; measurements of power factor and dielectric constant at ultra-high frequencies; round-robin tests of power factor and dielectric constant for glass; and the significance of tests of insulating materials. Two tables of contents, one listing standards in numeric sequence, are given and, for the first time, a detailed index.

Time and Timekeepers. Including the History, Construction, Care, and Accuracy of Clocks and Watches. By W. I. Milham. Macmillan Company, New York, 1941. 616 pages, illustrated, $8^1/_2$ by $5^1/_2$ inches, cloth, $1.95.

This volume begins with a chapter on time and time measurement. Succeeding chapters trace the origin of the sundial, celpsydra, and other early timekeepers up to the year 1360. From this point a detailed history of timekeeping mechanisms is given, including special movements, electric and precision clocks, certain famous clocks and watches, and information about the important American and European clock- and watchmakers.

The Radiotron Designer's Handbook. Third edition, edited by F. L. Smith, published by Wireless Press for Amalgamated Wireless Valve Company, Sydney, Australia; distributed in the United States by RCA Manufacturing Company, Harrison, N. J., 1941. 352 pages, diagrams, etc., 9 by $5^1/_2$ inches, cloth, $1.

Intended for those interested in the fundamental principles of practical circuit design, this manual presents material on audio-frequencies; radio frequencies; rectification, filtering, and hum; receiver components; tests and measurements; valve characteristics; general theory; and miscellaneous data. Bibliographies accompany the more important chapters.

Aerial Bombardment Protection. By H. E. Wessman and W. A. Rose. John Wiley and Sons, New York; Chapman and Hall, London, 1942. 372 pages, illustrations, etc., $9^1/_2$ by 6 inches, cloth, $4.

Presents a discussion of measures which can and should be undertaken to make building construction resistant to the effects of bombing, at reasonable cost. Characteristics of bombs, air raid shelters, evaluation of shelter zones, and camouflage are considered. A brief statement of other engineering problems related to aerial bombardment is also included. The material has been developed with particular regard for American structural and architectural practice.

A Short History of Science to the Nineteenth Century. By C. Singer. Clarendon Press, Oxford, England; Oxford University Press, New York, 1941. 399 pages, diagrams, etc., 9 by $5^1/_2$ inches, cloth, $3.75.

This elementary survey of the development of knowledge of the material world discusses the emergence of the leading scientific ideas from Greek times to the nineteenth century. Intended for the general reader, scientific problems are treated in the order in which they have arisen, rather than along the lines of the separate sciences.

Heating, Ventilating, Air Conditioning Guide, 1942. Twentieth edition. Published by the American Society of Heating and Ventilating Engineers, New York. 1160 pages, diagrams, etc., cloth, $5 (with thumb index, $5.50).

Aims to present the latest available, authoritative information on heating, ventilating, and air conditioning. A section on technical data containing reference material on design and specification is included as well as a manufacturers' catalog of modern equipment, and the membership roll of the society.

Practical Marine Diesel Engineering. By L. R. Ford. 3rd edition. Simmons-Boardman Publishing Corporation, New York, 1941. 590 pages, illustrated, $9^1/_2$ by 6 inches, cloth, $5.00.

Construction, operation, and maintenance of marine Diesel engines are explained from the viewpoint of the operating engineer. Developments in new types of equipment associated with motorship propulsion, such as couplings and superchargers, are discussed, also methods and requirements for obtaining a motorship license. Limited to American engines.

Mathematics For Electricians and Radiomen. By N. M. Cooke. McGraw-Hill Book Company, New York and London, 1942. 604 pages, diagrams, etc., $9^1/_2$ by 6 in., cloth, $4.

This book is intended to provide adequate mathematical background for solving practically all electrical and radio problems. Elementary algebra through quadratic equations, logarithms, trigonometry, elementary plane vectors, and vector algebra as applied to a-c circuits are included. The text follows an electrical rather than a purely mathematical arrangement.

Heat in Theory and Practice Essential to Refrigeration and Air Conditioning. By S. R. Cook. Nickerson and Collins Company, Chicago, Ill., 1941. 228 pages, diagrams, etc., $9^1/_2$ by 6 inches, cloth, $2.

The fundamental facts and theories of heat are presented in a simple manner for the student interested in refrigeration and air conditioning with the intention of giving information essential to the solution of problems which may arise in the study of refrigeration and air conditioning, from a text or from actual handling of refrigerating and air conditioning machinery.

Mathematics of the Shops. By F. J. McMackin and J. H. Shaver. D. Van Nostrand Company, New York, 1942. 444 pages, illustrations, etc., 9 by $5^1/_2$ inches, cloth, $2.50.

Intended for use in vocational high schools and apprenticeship classes. The fundamentals of arithmetic, algebra, geometry and trigonometry are explained in simple language, and basic problems which arise in the building trades and in electrical and machine shops are discussed. Special consideration is given to acceptable trade and technical practices.